PETROLEUM PROCESSING

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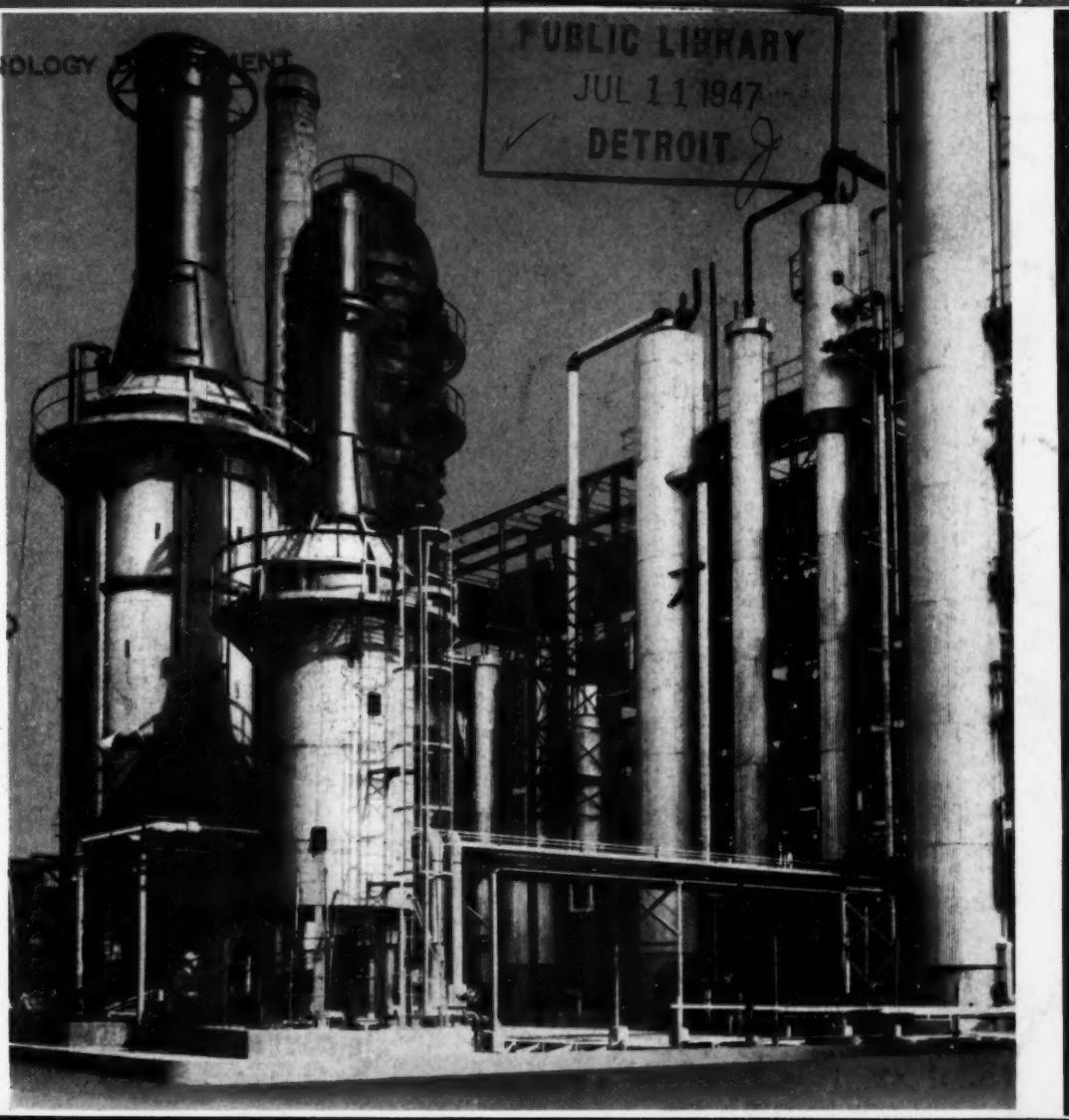
New Solvent Lube Oil Plant



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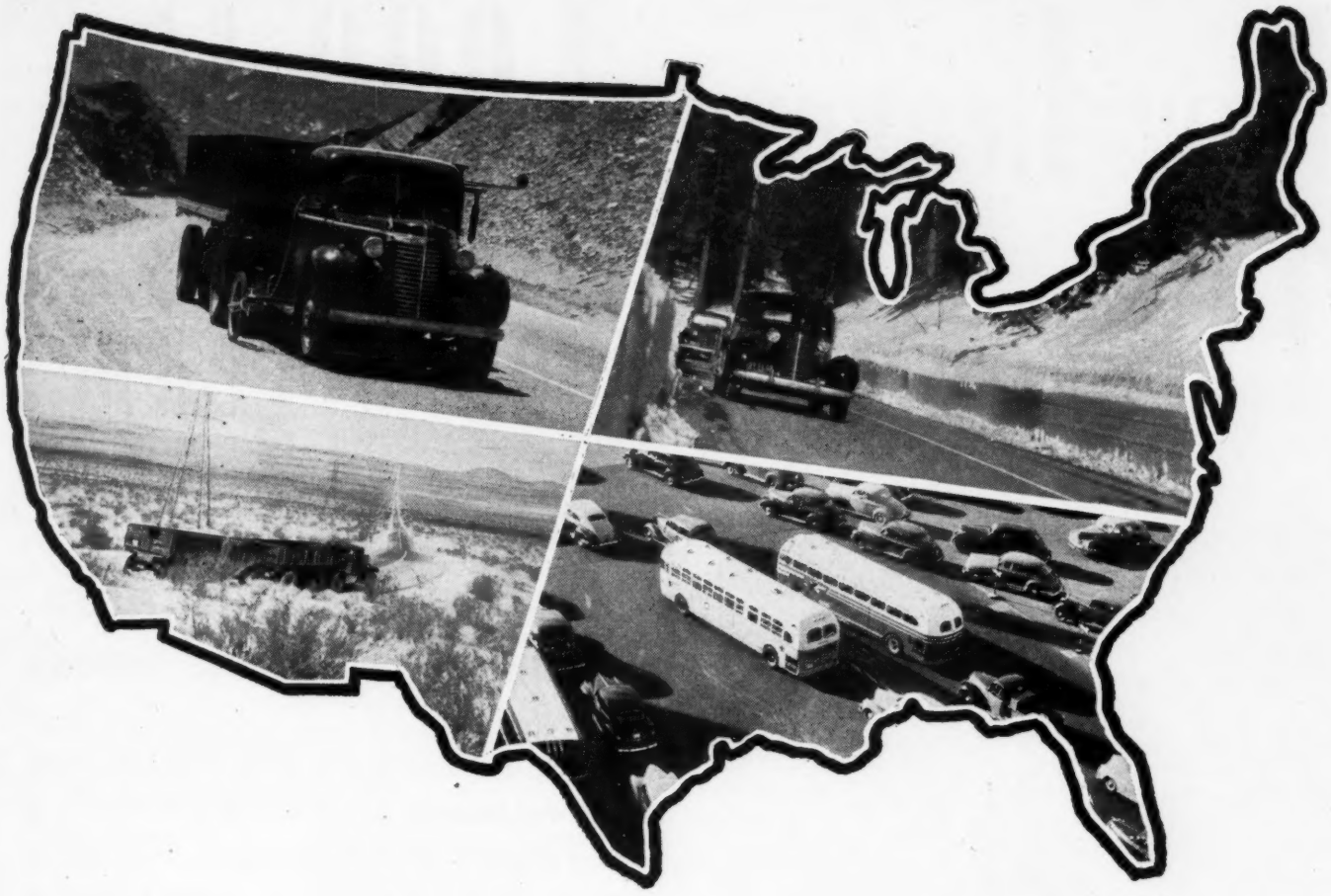

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IN ONE small area surrounding the Ethyl Corporation's San Bernardino (California) research laboratory is a representative cross-section of a large proportion of the nation's roads.

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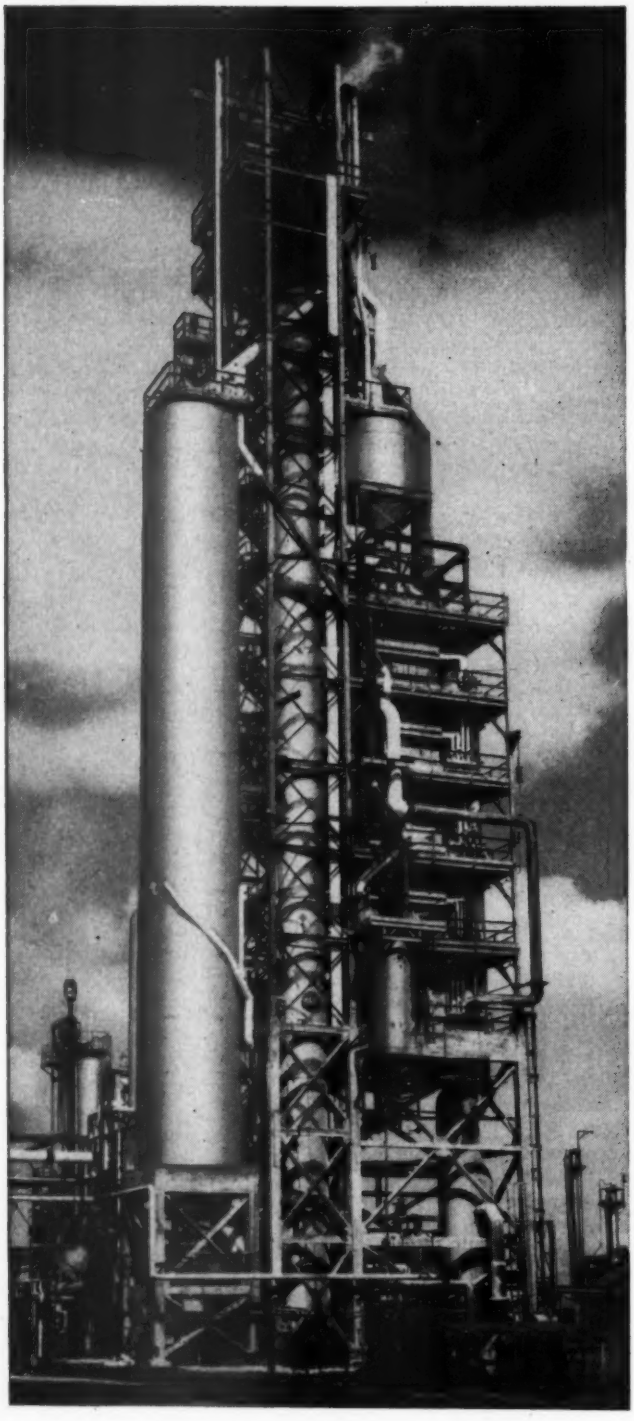

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PETROLEUM PROCESSING

Of Crude Petroleum and Natural Gas
For Fuels, Lubricants and Petrochemicals
REFINERY OPERATION, MAINTENANCE, EQUIPMENT, DESIGN

FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

STAFF FEATURES

• POINT OF FOCUS of oil company automotive engineers at the SAE Summer Meeting at French Lick was the unveiling of GM's new experimental 12.5 to 1 compression engine. Present—and the only staff representative of any oil journal—was one of the editors of Petroleum Processing, to hear the new development described by "Boss" Kettering, listen to the discussion by oil company technologists on its fuel requirements, even to ride in the demonstration car powered by the new high compression engine.. His article is on pg. 485.

●

• THIRD ANNIVERSARY OF TIPT. Just three years ago the editors launched a special feature designed to review developments in industrial and scientific fields genera'ly which were of importance to the oil industry. Called "Keeping Up with the News", this feature immediately became popular with readers.. In this present era of accelerated technology, .however, .tomorrow's .developments push hard on the heels of today's news so that a longer range point of view was seen necessary in considering the subject material for the feature. "TOMORROW in Petroleum Technology" was adopted as a more fitting title and it so stands today. The July installment is on pg. 490.

●

• THE API REFINING DIVISION resumes its Mid-Year meetings after a lapse through the wartime years. Three Petroleum Processing writers were present at the sessions in St. Louis June 2-3 where papers on practical refining subjects and reports on committee and special research work were presented. See pgs. 549, 553 and 554.

THIS MONTH'S COVER

Photo on the cover is the new furfural solvent lubricating oil plant at the Coffeyville, Kans., refinery of the Cooperative Refinery Assn. Features of its design and construction are described and a review of operations in the break-in period presented in the special article on pg. 492. Authors are Louis C. Brown, chief refinery engineer, Cooperative Refinery Assn., and Claud F. Tears, vice-president of Process Engineers, Inc., designer of the new lube oil unit.

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JULY, 1947

Top scientists in petroleum and automotive industries, Robert E. Wilson, (left), board chairman, Standard Oil Co. (Indiana), and Charles F. Kettering, (right), just retired as research director for General Motors Corp., at the SAE meeting in French Lick

High Compression, Fuel Saving Engine Practical, Kettering Tells SAE

By WILLIAM C. UHL
Equipment Editor
PETROLEUM PROCESSING

AS FAR as design and construction features are concerned, the way is open for the commercial manufacture of automobile engines with compression ratios up to 12.5 to 1, similar in design to the engines in present-day cars, and operating on fuel approaching 100 Research octane number.

This was the consensus of both automotive and petroleum engineers attending the Summer Meeting of the Society of Automotive Engineers at French Lick, June 1-6. They heard the story of the development of the new high compression engine, about which many reports have been heard since last January, explained by Charles F. Kettering, now research consultant and a director of the General Motors Corp. "Boss" Kettering retired as vice president and general manager of GM Research Division June 2.

Also, as was this writer, SAE members and guests were given a ride over the rolling Indiana hills around French Lick in one of the two current model Oldsmobiles equipped with six-cylinder 12.5 compression engines. Very little difference was to be found in performance from the same model "Olds" with today's conventional engine.

Principal economic feature claimed for the high compression power plant is a fuel saving of about one third as compared with the consumption of today's cars. The compression ratio chosen was 12.5 to .1 because early experiments with a single cylinder laboratory engine had shown that most of the gains could be obtained at that ratio.

Chief differences in design between the new engine and a stock model are 1) overhead instead of L-head valves, 2) 181 cu. in. as compared to 238 cu. in. displacement, 3) smaller bore and stroke, 4) general strengthening of operating parts with a seven-bearing cankshaft, 5) a compression pressure about 2½ times greater.

The new engine weighs no more per horsepower than stock engine. In answer to one question, Dr. Kettering said it would not cost more than about 5% more to make the high compression engine than the 6.4 compression engine used today.

Both automotive and petroleum engineers at the French Lick meeting pointed out that the transition to commercial production of engines in this compression range would be gradual, with many economical factors involving both the petroleum and automotive industries.

The work on high compression engines which General Motors resumed after the war has demonstrated said Dr. Kettering, that with proper attention to structural design an automobile engine can be operated at compression ratios as high as 12.5 to 1 without any sacrifice in smoothness. Such an engine would give impressive gains in economy over the entire driving range he stated.

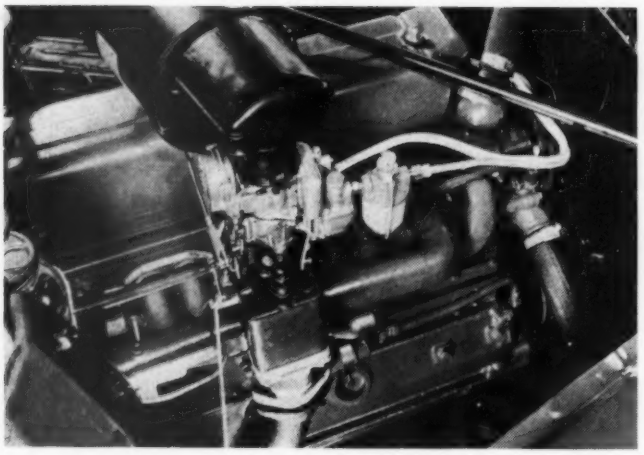
"If, when new engine designs are made, the economics of higher compression ratios are taken into consideration, these engines can always be adapted to the currently available fuels. As suitable fuels reach the market the compression ratio could be increased without other major changes. This would make for large savings in retooling costs.

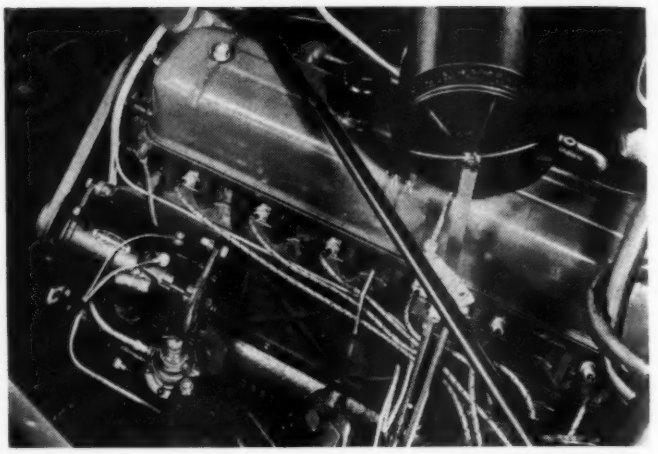
When GM resumed work on experimental engines after the war, they had available several thousand gallons of pure triptane and a plant in operation to make it in sufficient quantities for a long range program of engine development.

The use of triptane made it possible, Dr. Kettering explained, to build an engine in the laboratory and uncover the mechanical problems of high compression operation separately from the fuel by gradually reducing the fuel's antiknock value and thereby evaluating the engine factors by themselves as they became apparent.

GM technologists then studied the effects of three different fuels on performance — di-isobutylene, iso-octane, and an experiment test fuel of 99 Research and 85 ASTM octane rating. This latter fuel it is understood, could be made and sold in large quantities at a comparatively small premium, Dr. Kettering stated.

A condensation of Dr. Kettering's paper begins on the next page.





These views of each side of the 12.5 compression engine as installed in a stock model Oldsmobile show outward appearance to be little different from conventional engine

MORE EFFICIENT UTILIZATION of FUELS

By CHARLES F. KETTERING

Vice president, General Motors Corp., and General Manager, GM Research Laboratories Division

Abridged Version of Paper Under the Same Title, Presented at the Society of Automotive Engineers Summer Meeting, French Lick, Ind., June 1-6, 1947.

THE KEY to higher efficiencies in internal combustion engines is in the increase of the compression ratio. In times past, attempts to utilize this important principle in spark ignition engines have run into fuel knock. The large gains in Diesel engine efficiency are known to be due mainly to compression ratio increase. At present, Diesel engines are operating with a range of compression ratios between 14 and 17 to 1, and with brake thermal efficiencies as high as 38%. If equivalent compression ratios can be used in spark ignition engines, the same full throttle brake thermal efficiencies should be obtained.

The reason automobile engines are in the range of about 6.5 to 1 compression ratio with a maximum of about 25% thermal efficiency is because engines and fuels have not yet been adequately matched.

The knocking characteristics of a fuel are related to the molecular structure in a very definite order. It was the discovery of this property of hydrocarbons which expedited the development of high octane fuels. Fig. 1 illustrates the relationship of molecular structure of one family of hydrocarbons, the paraffins, to critical compression ratio of a special test engine under severe engine conditions.

Normal heptane, the low end of the octane scale, has a critical compression ratio a little under 3. Iso-octane, the high end of the scale, has a value of about 6.5. Triptane, the top of the heptanes, has a value of 10.5. These values, of course, only pertain to these particular engine conditions which were chosen for convenient illustration. They would be greater under milder operating conditions.

Triptane has been operated at compression ratios as high as 14.4 clear or 18 leaded. As can be seen, many other hydrocarbons have anti-knock quality. The petroleum chemist works to produce these higher octane fuels in developing refining practice.

An interesting thing about these various hydrocarbons is the way lead behaves in them. The addition of 3 ml./gal. of lead to heptane raises its critical compression ratio about 0.5 units. The same addition of 3 ml./gal. of lead to iso-octane raises the critical compression ratio 4 units. The same addition to triptane runs it off the measuring scale.

Triptane, or 2, 2, 3-trimethyl butane, is one of the best fuels known from the standpoint of knock. It was first tested in an engine in 1926. In 1943 a small scale pilot plant was completed to make pure triptane by a process developed in our laboratories.

When it is used in experimental work, the fuel limitations on increasing the compression ratio to as high as Diesel ratios of 15 to 1 are eliminated.

Since our scale of knock rating does not go above 100, and is arbitrary at best, we cannot say exactly what the knock rating of triptane really is. We do have evidence that its performance number with TEL added may be as much as 500 under some engine conditions compared with 100 for iso-octane.

The General Motors triptane plant was built to supply triptane and other hydrocarbons in sufficient quantities for engine development. At the end of the war General Motors Research was in the same position as all of you in the petroleum and automotive industries. We were again faced with the peacetime problems of making the best engines possible. The whole industry was thinking of new engines for the future. The petroleum industry needs to know what type of fuel will be required by these new engines so the new refining facilities will be capable of supplying them.

Triptane made it possible to build an engine and uncover the mechanical problems separately from the fuel by gradually reducing the antiknock value of the fuels and thereby evaluating the engine factors by themselves.

These tests have shown that higher compression ratios present no insurmountable engineering problems. Concern over engine roughness, ignition problems, high friction, idling, and other factors has been shown to be the result of carrying low compression designs beyond their range.

The two industries can only continue to progress by working together. This report can be considered as a survey of at least one route that can be taken in the development of spark ignition engines.

Development of Six Cylinder Engine

The tests on the high compression single cylinder engine in the laboratory

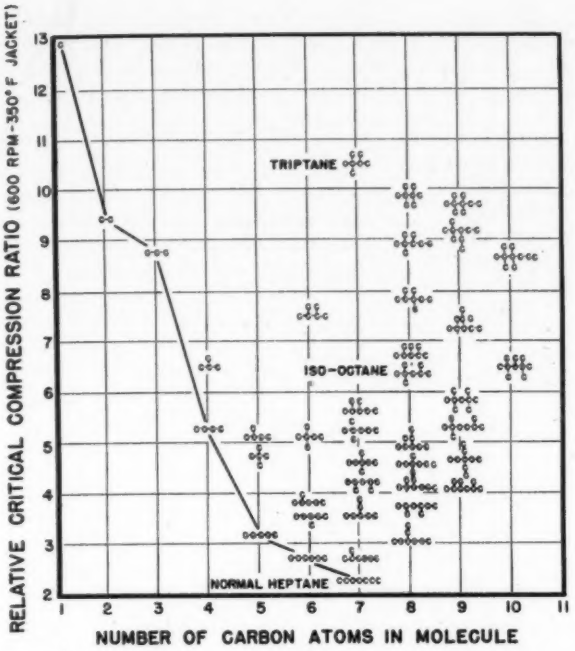


Fig. 1—Effect of molecular structure of paraffin hydrocarbons on the relative critical ratio

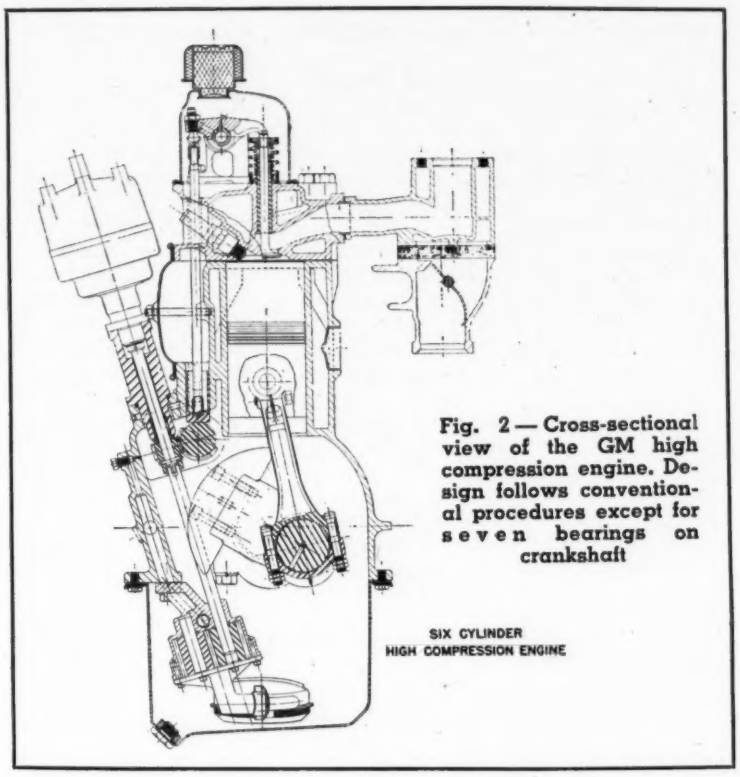


Fig. 2 — Cross-sectional view of the GM high compression engine. Design follows conventional procedures except for seven bearings on crankshaft

using triptane, plus Diesel experience, gave the basic data for designing and building a six cylinder engine which could be installed in a car.

The single cylinder engine of 30 cu. in. displacement was built to explore the range of compression ratios between 6 to 1 and 15 to 1. It had overhead valves in order to maintain the most effective use of the available combustion space for clearance and breathing capacity. This also kept surface to volume ratio to a minimum. Bore and stroke were 3-⅜ x 3-⅜ in. The engine was designed to give the required strength and rigidity for compression ratios up to 15 to 1, otherwise it was conventional in design.

Compression ratio was varied through the desired range in five steps by changes in pistons. The basic data obtained on the effects of compression ratio on performance and efficiency were then incorporated in the design of a six-cylinder powerplant.

The compression ratio chosen for the six cylinder engine was 12.5 to 1 because the single cylinder data had shown that most of the gains in efficiency on this cylinder construction could be obtained at this ratio.

The plan was to build an engine which would operate at this ratio and still be as acceptable to the drivers as current engines, thus showing it is possible to use high compression ratios in an automobile engine when the fuels are at the gas station.

If, when new engine designs are made, the economics of higher compression ratios are taken into consideration, these engines can always be adapted to the currently available fuels. As suitable fuels become available, the compression ratio could be increased without other major engine changes. This would make for large savings in tooling costs on new engines.

In short, we wanted to determine what the foundation had to be to carry the maximum loads the engine would ever be asked to carry. This engine is considered a long range experiment, not a finished production engine.

To give a good base line for comparison, a standard 1946 production car was chosen. The displacement of the high compression engine was selected in accordance with the single cylinder test so that it would deliver approximately the same horsepower throughout the speed range as the standard comparison engine. It was also designed to be readily interchangeable with the standard engine so that it could be installed in the car without difficulty.

With approximately the same horsepower, the same axle ratio, and the same weight, the two cars should have equal performance. No weight limitation was placed on the design of the high compression engine. The object was to provide a mechanically sound test engine in which weight could be considered later.

Table 1 shows a comparison of the high compression and 1946 stock production engines as to specifications and performance factors. While it was planned to use triptane as fuel for the early work on the six-cylinder engine, a compression ratio high enough to require triptane was not used. The ratio was chosen to obtain the greatest practical part of the gains of high compression ratio as indicated by the single cylinder tests. If we had been building a triptane engine, the ratio would have been considerably higher—probably 15 or 16 to 1.

The engine was designed according to rather conventional procedures except that it was made rigid enough to carry the higher load imposed. Our wide Diesel experience helped greatly on this problem because the stresses involved are comparable.

Our experiences on both the single cylinder and the first six-cylinder engine led to the design of a second experimental engine, once we found no special difficulties from roughness or high friction. Fig. 2 shows cross-sectional views of this design. The engine weighs no more per horepower than stock engines.

In performance tests on the dynamometer, we obtained a minimum specific fuel consumption of less than 0.40 lb./brake horsepower hour in comparison with 0.54 for the stock model. This is a gain of about 35%, checking very

TABLE 1—Comparison of High Compression and Standard Engines

	H. C.	Standard
Number of cylinders	6	6
Valve arrangement	Overhead	L-Head
Bore and stroke	3⅜x3⅜	3½x4⅛
Displacement—cu. in.	181	238
Compression ratio	12.5	6.4
Comp. pressure at 2000 rpm.	420 psi	165 psi
Peak pressure at 2000 rpm.	1150 psi	525 psi
Engine torque at 2000 rpm.	154	163
Mech. efficiency at 2000 rpm.	85%	81.5%
Maximum brake horsepower.	95 @ 3600 rpm	85 @ 3400 rpm
Miles/gal. @ 49 mph.	26.5	18.5
Rear axle ratio	3.63	3.63
Car test weight, lbs.	4110	4110

well with the single cylinder test data previously obtained.

It is also comparative with full throttle Diesel fuel consumption, showing that, at equivalent high compression ratios, it makes little difference whether there is compression ignition or spark ignition. Both types of engines give high full load fuel economies.

Throughout the test speed range of about 1000 to 3000 rpm, the high compression engine lost less heat per hp. through the exhaust and cooling water. Heat rejection to cooling water was almost 30% lower in the high compression engine than in the stock engine.

A series of fuel consumption cross-section curves at various speeds from 1000 to 3000 rpm was then run as shown in Fig. 3. This set of curves can be used to predict the car fuel consumption at any load, rear axle ratio, or with automatic transmissions. The calculated road load has been spotted at each speed and a dotted curve drawn which would indicate the road load specific fuel consumption.

Curves in Fig. 4 were calculated from these and similar data on the stock engine and show the relation between miles/gal. and per cent load at 2000 rpm, or in this case, 40 mph. This illustrates a very important characteristic of the economy gains resulting from higher compression ratio.

The gains are consistently large throughout the entire load range. Similar dynamometer data taken at other speeds show the same tendency. From this it was concluded that the high compression engine should show these large gains on road tests under all driving conditions.

Road Tests on Six-Cylinder Car

An engine in a car on the road is final proof of engine performance. The six-cylinder high compression engine was installed in one of two of the same model stock automobiles, both equipped with Hydra-Matic transmissions.

Both cars have been run on comparative road tests for many months. Both give normal, smooth, operation. Performance and feel are about the same. It is impossible to tell from driving the two cars which one is which, although at high speed the high compression car is somewhat faster.

A comparison of constant speed level road economy of the two cars is illustrated in Fig. 5. Under these conditions, the high compression car gives from 35 to 40% better economy in mpg than the standard car. At 40 mph the standard car has a fuel economy of 18.5 mpg while the 12.5 ratio car has an economy of 26.5 mpg, about a 40% improvement. At 60 mph the saving is 35%.

While these data are important from an engineering standpoint, they give only part of the story, because automobiles are not driven on level roads at constant speed very much of the time. Approximately two-thirds of the gasoline is consumed in city driving where a large percentage of the operation is transient and requires the entire throttle range of the engine.

It was shown previously, in Fig. 3, that based on dynamometer tests, the 12.5 ratio engine should show about the same gain in economy over the standard car regardless of load or driving conditions. In order to check this a number of cross-country trips were made where both cars were driven together under the same speed and traffic conditions.

The average gain was about 33% over a large number of such trips under widely varying road conditions. Up to 50 mph, the gain was 35%; up to 70 mph, it was 33%. Several extended trips made entirely in city traffic show gains of over 40%, which is of major importance in view of the large quantity of fuel burned under these conditions.

Many preconceived troubles failed to materialize after the engine was running. Engine roughness was eliminated by proper structural design. With some modification of the ignition coil winding and core material, conventional 6 volt ignition has proved adequate.

Cold starting had not been a problem at temperatures encountered in the Detroit area during the past winter. It was thought that the effect of combustion chamber deposits might become critical at high compression ratios. Almost 10,000 miles of driving with a leaded fuel has failed so far to develop any trouble.

Antiknock Requirements

Fig. 6 is a representation of the performance of three widely different types of fuel which may be of interest. Di-isobutylene is an extremely sensitive fuel as indicated by its Research octane number, equivalent to iso-octane plus 0.5 ml. TEL, and ASTM octane number of 88. Iso-octane is the primary reference fuel, with zero sensitivity by definition.

The experimental test fuel was a sensitive type of gasoline which was produced by catalyic cracking and, with 1.5 ml. TEL, had a Research octane number of 99 and an ASTM rating of 87. It is understood that such a fuel could be made and sold in large quantities at a comparatively small premium.

Several very significant things about the performance of these three fuels in this engine are illustrated in Fig. 6.

First—That it is possible to operate the 12.5 compression engine with 99/87 octane gasoline, although with some slight detonation at speeds above 55 mph.

Second — That, with comparatively small changes in spark advance, an engine of this type can be operated satisfactorily over the entire speed range with a fuel of approximately 99/87 octane number.

Third—The relatively high ratings of di-isobutylene and of the experiemental test fuel with respect to iso-octane are better than would be expected from an interpretation of the Research and ASTM ratings.

Summary

In this work it has been shown that, in a broad way, increases in economy of one-third can be expected when compression ratios are increased to 12.5 to 1. It appears that, with a little cooperative work between the petroleum and auto-

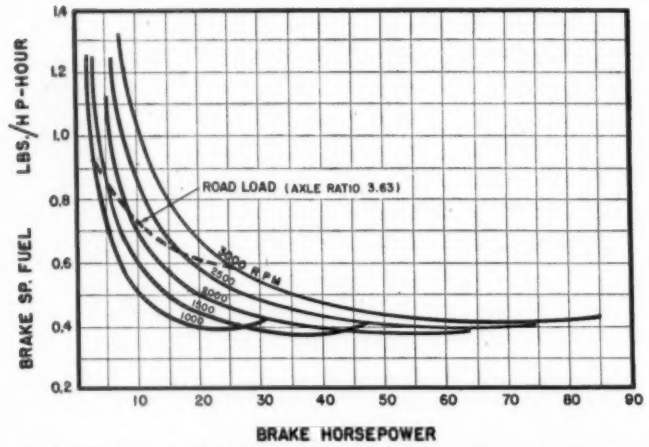


Fig. 3—Economy of the six cylinder high compression engine at fractional loads from dynamometer tests

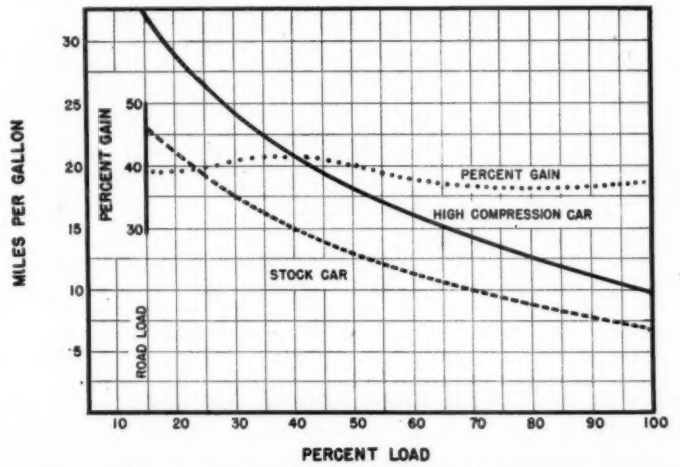


Fig. 4—Economy of the six cylinder high compression engines at fractional loads and constant speed of 40 mph

mobile industries, high compression ratios are not very far off.

The jump to 12.5 ratio cannot be made at once for various reasons. The almost 30 million vehicles on the road do not require higher octane gasolines, and it will be many years before they are worn out.

While it would not be possible for the automobile industry to entirely retool to obtain the full advantage of 12.5 to 1 in any year, neither would it be possible for the oil industry to shift to the production of high octane fuel over night. The changes can come as rapidly as automotive engineers and petroleum chemists learn how to commercialize the possibilities.

While it is recognized the trend toward higher compression ratio must be gradual and orderly, it is believed that this trend may possibly be greatly accelerated if the required correlation between fuels and engines is taken into consideration while making new engine designs for the immediate future.

We have not reached the limit of engine efficiency. There is much that can be done with the automobile as we put into practice the new things we learn in the different fields. Thus we are assured of continuous progress for many years to come.

Discussion

A transition to the required fuel for a 12.5 compression engine would also be gradual in the petroleum industry, W. J. Sweeney, vice-president, Standard Oil Development Co., pointed out in the discussion period following Mr. Kettering's paper.

"We look forward to a period of slow but progressive development of engines and fuels which will result in economic benefits to the consuming public," said Mr. Sweeney. "Time will be needed for the petroleum industry to install facilities for making such fuels economically, and care must be taken by both the automotive and petroleum industries to keep the engine requirement and the fuel quality in step so that the public interest will be best served."

In some ways, the oil refiner can face the problem in an even more optimistic spirit than the engine builder, Mr. Sweeney believes.

"While the automotive industry has been frozen in its designs by several years of war; the petroleum industry over the same period has developed—on account of the war demand for aviation gasoline—processes capable, when installed on a sufficient scale, of manufacturing gasoline of higher quality than has ever been manufactured before," he stated.

To support the economic justification of this trend in the two industries, Mr. Sweeney presented some figures based on studies by the Esso Laboratories over a period of years on the effect of compression ratio on economy. This work was an attempt to answer to their own satisfaction the question of return

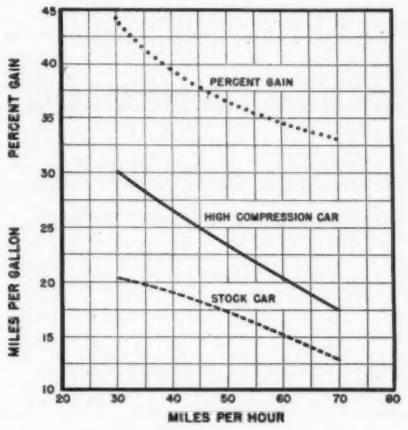


Fig. 5—Comparison of constant speed level road economy of the high compression and the standard cars

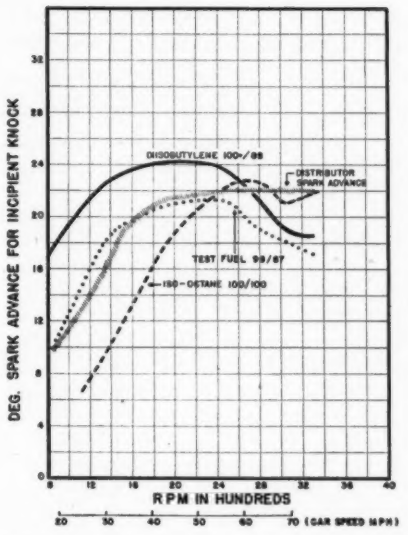


Fig. 6—Knock characteristics of three fuels in the high compression car as affected by speed and spark advance

to the public in added mileage for the same car performance versus the cost to the petroleum refiner added manufacturing.

The data used were: mileage vs. compression ratio; compression ratio vs. octane requirement; and octane number vs. cost of manufacture. They have been found to be in approximate agreement with the data obtained by GM Laboratories on the 12.5 compression engine, and in agreement with the thermodynamic rules which apply to heat engines, Mr. Sweeney stated.

Esso found that increasing compression ratio from 6.6-1 to 9-1 resulted in 22% more miles per gallon, and that an increase from 6.6-1 to 12.5-1 gave about a 40% fuel economy in miles/gal., the figure claimed for the Kettering engine.

Studies on octane requirements vs. compression ratio indicated that a representative present-day car of 6.6 ratio needs a fuel of 76.5 ASTM and 85 Research octane. A car of 9 ratio requires a fuel of 84 ASTM and 96.5 Research, but gives 22% better economy.

Assuming a 20c/gal. consumer value for today's gasoline, the fuel required by the 9 compression ratio engine would be a little over 4c/gal. added value to the customer, for a total at the pump of 24c.

"This added value to the customer would probably be appreciably greater than the added cost of fuel manufacture," Mr. Sweeney said.

Two Pumps Offer Possibilities

Fortunately the oil industry today has a two-pump system at service stations delivering both regular and premium grade gasolines, therefore any venturesome company could easily switch over and make the high compression fuel readily available now, it was brought out by Dr. J. B. Macauley, director of engineering, Ethyl Corp.

He added in agreement with Mr. Kettering, however, that the proper course would be to modify the high compression engine to meet present fuels and then develop both hand in hand.

Dr. Robert E. Wilson, board chairman, Standard Oil Co. (Indiana), who introduced Mr. Kettering, concurred in the opinion as to the adaptability of the two-pump system. However, he warned that there might be certain economic factors which the petroleum industry would have to consider. For example, the demand for the products now delivered from the two pumps is roughly equivalent. But, with an early or premature introduction of the high compression fuel, the low demand in the beginning would not justify discarding a good saleable product so as to handle it with existing facilities.

"The two-pump system of course is not new in the oil business," stated Mr. A. G. Culbertson, Shell Oil, "we've always had a few octane numbers to spare."

Mr. Culbertson believes the fuel must advance ahead of the engine from an economic standpoint. The average passenger car consumes about 1½ times its own weight in fuel every year. During World War II, the oil refiners spent billions of dollars to raise the octane rating of fuel just a few points; but the demand from the military already existed so the refiners could realize a return in proportion to their investment, he brough out.

It is far more difficult to predict the future with respect to this new engine, according to Mr. Culberston. An automobile would use about a third less fuel. What will happen to the demand? Will more people buy cars because of that? Will cars be driven more miles per year? Or will the relatively unknown values of cost of car and fuel have a reverse effect? All these points must be answered before a prediction can be made.

The high compression engine would probably cost about 5% more, Mr. Kettering said in answer to Dr. Wilson's question about comparative engine costs.

TOMORROW

. . . IN PETROLEUM TECHNOLOGY

Current technological and economic developments discussed here in the light of their future bearing on petroleum refining operations include:

- **TIPT celebrates third birthday.**
- **Hydroforming providing valuable chemical intermediates.**
- **Aromatics from petroleum increase in importance.**
- **DuPont announces nylon from furfural.**
- **New automobile will have "postwar" features.**

TIPT Celebrates Third Birthday

THREE years ago this issue, PETROLEUM PROCESSING (then the *Technical Section* of NATIONAL PETROLEUM NEWS) inaugurated a new feature series, "Keeping Up With The News," designed "to discuss new developments in scientific and industrial fields in general, as well as in the petroleum industry, and to report on their possible effect in: (1) providing some new method or process which may be put in operation in the petroleum field, (2) providing new products and new uses for petroleum products, (3) supplying new products or sources for products which may compete with those from petroleum or possibly substitute for them."

As phrased in the introduction of many of the earlier articles; "this series is prepared in an effort to correlate current information on certain of the important happenings in scientific and industrial fields in such a manner that its present and future technical-economic relationship to the petroleum industry may be more clearly understood." Realizing that material so interpreted involved more than "keeping up with the news," it was decided, early in 1946, to continue this series under its present, more informative title, "Tomorrow in Petroleum Technology."

During the past three years, more than 200 commentaries on current developments have been presented, dealing with subjects ranging from petroleum chemicals to atomic energy. Not being possessed with second sight, the author has not always attempted to say "since this is so, that must result." Instead, the policy which has been followed is one in which new developments are weighed in the light of past happenings and related current events, and any predictions for the future are intended to be those which seemed based on the logic of the particular situations. Since science and technology have a way of making today's logic seem foolish tomorrow, it is freely admitted that errors of judgment have sometimes been made.

It is important to keep in mind that "Tomorrow in Petroleum Technology" does not pretend to be either a journal within a journal or an omnibus of technical-economic news comments. Its function centers around the analysis of happenings which are usually reported elsewhere only in factual outline, or developments which would otherwise wait for months for full-scale feature article development. As such, it serves to supplement PETROLEUM PROCESSING's well-rounded coverage of the technical aspects of the fields related to the processing of petroleum.

In the future, "Tomorrow in Petroleum Technology" will continue to offer its interpretations of events of present and potential importance to petroleum processing, in whatever manner and to whatever degree is desired by the readers of PETROLEUM PROCESSING.

Hydroforming Providing Chemical Intermediates

EVEN at the risk of stressing petroleum aromatics too heavily in a single issue of this series, it is certainly of interest to note that hydroforming operations, vital source of toluene in the recent war, are currently producing quantities of xylenes for chemical and solvent purposes.

As is well known, the process of hydroforming involves the catalytic cyclization of aliphatic hydrocarbons and the subsequent dehydrogenation of the acylic intermediates (and such naphthenes as occur naturally in the feed stock) to yield aromatics in high percentages. For toluene (C_7H_8) manufacture, a C_7 cut was naturally used; "the postwar twist to make xylenes (C_8H_{10}) instead of toluene is basically one of changing the feed stock from a C_7 to a C_8 cut."(1)

(1) Anon., *Chemical Industries* 60, No. 5, 763 (1947), "What's New—Second Wind for Phthalic."

As mentioned elsewhere in this article, *o*-xylene is of growing importance as a raw material for phthalic anhydride manufacture, especially because the "normal" raw material, naphthalene, is in short supply despite peak operations of coal tar distillers. Theoretically, the 780,000,000 gallons of coal tar produced annually at the wartime peak should have contained around 600,000,000 lbs. of naphthalene. However, peak production of naphthalene during the war was just a little over 300,000,000," and the complexities of the situation, in which "the price and supply of naphthalene are inextricably bound to markets for creosote oil, pitch, etc.," and coal tar production bound to steel operations, are such that "it is unlikely that the annual production of naphthalene will greatly exceed 300,000,000 lbs. in the next few years. An outside figure would be 400,000,000 lbs."

Last year, the production of phthalic anhydride proceeded at only two-thirds of capacity rate (173,000,000 pounds per year) because of the shortage of naphthalene. To further complicate the situation, naphthalene is in growing demand for the production of insecticides, detergents, plant hormones, rubber chemicals, and dyes.

As was widely reported, the Oronite Chemical Co. (subsidiary of Standard of California) began the production of phthalic anhydride from hydroforming-derived *o*-xylene in 1945, but its output, only 5% of national capacity, has failed to help the shortage materially. Within the past few months, however, "two major oil companies have offered tank-car deliveries (of *o*-xylene); one has actually made shipments."

It should be noted, however, that *o*-xylene comprises only 15-30% of the crude hydroformate and that, therefore, "the overall economy of the operation depends on the markets for the other constituents, chiefly *m*- and *p*-xylenes. These currently find their major use as solvents. At the moment, solvent grades are bringing 22 to 23c/gal.; the ortho isomer (over 90% purity) may fetch around 30c/gal."

While petroleum producers of *o*-xylene do not claim, therefore, that it is more than a supplement for naphthalene in the production of phthalic anhydride, their quoted price—4 to 5¼c/lb.—is almost competitive with naphthalene at 4¼c/lb. Yields of phthalic anhydride from *o*-xylene are not quite comparable to those from naphthalene, although theoretical yields are 20% higher on a weight basis.

"Conservative estimates (of potential phthalic anhydride demand) run around 200-250% of last year's production." While certain of the other raw materials also needed for the production of phthalic derivatives (alkyd resins, vinyl resin plasticizers, etc.) are also in short supply, "there is real hope of boosting production" for all of these. However, "with naphthalene tied to steel, *o*-xylene is the

best immediate hope for phthalic anhydride."

Furthermore, it is not at all unlikely that other petroleum processors than Oronite will someday produce phthalic anhydride directly. "If the price competition between *o*-xylene and domestic or imported naphthalene ever gets too stiff, more oil refiners may find the stable price of phthalic a better haven."

Aromatics from Petroleum Increase in Importance

TO QUOTE from a reent journal,(2) "toluol from petroleum is now a regular item in the market. Industry spokesmen guess that it makes up about 15% of the current supply. As yet it appears that a comparable supply of benzol has not yet begun; but it threatens, so they say."

Going into further detail on this subject, another journal(3) comments editorially on the recent flood of aromatic chemicals from petroleum—toluene, still marketed by Shell at Wood River; phthalic anhydride, produced from *o*-xylene by Standard of California and at least potentially by an Atlantic Coast purchaser of carlot quantities of *o*-xylene, which "has also been offered by Shell"; nylon, which has been produced "on occasion" from petroleum cyclohexane at the duPont Sabine River Works ("cyclohexane is now being offered by Shell"); and "cresylic acids from Shell and Oronite, polyalkyl naphthalenes and *m*- and *p*-xylenes from Oronite."

Elsewhere in the same issue is the report that "Shell Chemical Co. is about to break big news with acknowledgment of plans to make benzene from petroleum. This month (May) the mooted project moved closer to reality when Shell offered petroleum-derived benzene to several major consumers. Large scale output is on the horizon." Furthermore, "the newly-formed McCarthy Chemical Co. of Texas has stated that petroleum benzene will be one of its major products."

Chemical Industries also goes so far as to state: "Watch for major developments in petroleum-derived polynuclear aromatics. The widespread utilization of catalytic cracking has upped the percentage of aromatics in refinery fractions, and wider use of solvent extraction facilitates their recovery. Right now many of these potentially valuable extracts are being burned—because of the fuel shortage. Oil companies are too busy on a host of other projects to do much about them for the nonce. But the possibilities haven't been overlooked. Action can be expected within a year or so."

Getting back to present and definitely forecast petroleum aromatics, *Chemical Industries* conservatively editorializes that "it is realized that this emergence of petroleum based aromatics has been abetted by the great shortage that exists for practically all aromatic compounds, but it is questionable if the petroleum companies would start marketing these materials with such vim and vigor if they only intended to skim the cream off the present seller's market. In any event, whether the petroleum based aromatics will serve mainly to supplement the short supply of aromatic compounds that threatens to become chronic, or emerge as a major factor in the market, insurance has been set up against the wide variations in availability that are characteristic of products of the volatile steel industry and the unpredictable Mr. Lewis. Further, petroleum promises to provide large quantities of aromatics such as *m*- and *p*-xylene, which are available only to a minor extent from coal."

(2) McBride, R. L. and Hightower, J. V., *Chemical Engineering* 54, No. 4, 84 (1947), "Watching Washington — New Aromatic Sources."

(3) Anon., *Chemical Industries* 60, No. 5, 755, 756, 760 (1947).

Du Pont Announces Nylon from Furfural

THE petroleum industry, in its growing enthusiasm for the productive of "chemicals from petroleum," is sometimes prone to forget the fact that other raw materials, through research, may be found equally or more economic for the manufacture of the same chemicals.

Such is apparently the case for at least one of the nylon intermediates, hexamethylene diamine, which at present is rumored to be produced from the other nylon intermediate, adipic acid, in turn presently derived from coal-tar benzine or petroleum-extracted cyclohexane. In the future, however, much or all of the hexamethylene diamine may be produced from furfural in a plant which du Pont is constructing for this purpose at Niagara Falls.

As the petroleum industry well knows, furfural is produced from agricultural by-products. In the new nylon process, "furfural is catalytically decomposed to form furan, which is hydrogenated to the saturated cyclic ether, tetrahydrofuran. This compound is reacted with hydrogen chloride to yield 1,4-dichlorobutane, which is converted to adiponitrile by reaction with sodium cyanide. Adiponitrile is then hydrogenated to hexamethylene diamine."(4) Adiponitrile can also be hydrolyzed to adipic acid, but apparently this is not as economic as synthesis from benzene or cyclohexane.

Du Pont emphasizes the fact that this new process will not necessarily bring a reduction in the manufacturing costs of nylon in the near future. The point is made, however, for whatever it is worth, that the use of agricultural materials instead of coal or petroleum substitutes replaceable for irreplaceable resources.

Nylon from furfural is no real check in the steady trend toward chemical synthesis from petroleum hydrocarbons. Instead, it is a reminder that chemical companies are not, *per se*, partial to any given raw material and that to compete with them a petroleum company must also consider competing sources before entering into the production of a given chemical.

(4) Cass, O. W., *Chemical Industries* 60, No. 4, 612 (1947), "Oat Hulls—Adiponitrile—Nylon."

New Autos Will Have "Postwar" Features

IN THESE days when dressed-up models sell as new cars, with leading automotive and petroleum economists predicting that no drastic mechanical changes will occur in mass-produced cars until the 1949 or 1950 models, it is at least reminiscent of wartime predictions to note some of the advertised features of the "Tucker '48," expected to be "ready to drive later this very year."

The car, according to advertisements, will have rear engine drive, using "a flat opposed 6-cylinder, 150 horsepower engine." Of considerable interest is the revelation that this engine will employ "measured fuel injection," long discussed but not used commercially by other car producers. "Electronic high-frequency ignition" will be used, and the motor will have "higher power-weight ratio than any volume production automotive engine ever built."

It is more than interesting to note that in spite of this powerful engine and a 128-inch wheel base, the car "gets 30 to 35 miles per gallon at moderate speeds." Technical descriptions of this car are available elsewhere and it has been under development for many years by Preston Thomas Tucker, who has designed many racing cars.

The automobile industry has long debated the technical, economic, and marketing advisability of many of the features involved in this "Tucker '48," especially rear-engine drive and fuel injection. Whether other car manufacturers will follow suit, when the demand for cars slackens and time for a real mechanical change-over can be taken, is by no means clear, for public reaction to changes is hard to gage. Furthermore, the "Tucker '48" is now being advertised as "in the medium price field," which could very well mean (in today's parlance) that it will actually be priced well out of the mass market, a trouble apparently being encountered by the "Kaiser" and "Frazer" models.

In any case, it will pay the petroleum industry to keep an eye on cars promising "30 to 35 miles per gallon." Automobile demands for gasoline ten years hence are hard to predict; higher gasoline mileages seem certain, but so does a vast increase in the automobile population and in per-car yearly mileages.

NEW FURFURAL SOLVENT LUBE PLANT

By LOUIS C. BROWN
Chief Refinery Engineer, Cooperative Refinery Assn.
and
CLAUD F. TEARS,
Vice President, Process Engineers, Inc.

Improved design and control features provide economies in the operation of the furfural extraction unit installed at the Coffeyville refinery of the Cooperative Refinery Assn., in its general program for modernizing lubricating oil manufacturing facilities. Throughout the unit care has been taken to reduce solvent losses, a new type of raffinate and extract heater serving this end. The treating tower is operated under pressure, which eliminates the need for surge tanks for the raffinate and extract mixes. New instrumentation features give closer control of temperature in the treating tower. Three weeks of break-in operation on three types of charging oil have given a satisfactory High Viscosity Index, low carbon residue finished product.

A NEW furfural solvent lubricating oil unit costing $750,000 has just been placed on-stream at the Coffeyville, Kans., plant of Cooperative Refinery Assn. as the latest step in the program of modernizing facilities there. The new unit is designed to process 2200 b/d of dewaxed neutral oil (200 SSU viscosity at 100°F.) or 1050 b/d of dewaxed acid-treated bright stock (165 SSU viscosity at 210° F.) Construction, held up by the war, started in July, 1946, and was finished last May.

The solvent refining unit will be operated in conjunction with a new vacuum distillation unit to be completed by the end of July. Capacity additions are being made in present refrigerating and pressing equipment. Still other alterations planned for the lubricant-manufacturing section of the plant in the overall modernization program will cost over $3 million when completed. They include a new lube distillation unit and a newer-type dewaxing process. All told these improvements will provide for the production of an increased volume of premium quality lubricants at the Coffeyville refinery.

The furfural plant, which has recently completed a three-weeks' break-in run, was built under Texaco Development Co. license by Process Engineers, Inc., Dallas. The design, which incorporates many engineering features new to furfural units and eliminates others considered necessary in earlier units, also is the work of Process Engineers. Wyatt Metal & Boiler Works furnished many of the vessels in the installation.

Furfural solvent refining employs a solvent derived from agricultural wastes which is particularly distinguished through being non-corrosive and of low toxicity. The principle is the same as employed in other solvent extraction processes; namely that furfural has a selective solvent action toward the undesirable constitutents of lubricating oil fractions while desirable components remain undissolved. The mixture of oil and solvent splits into two distict phases following treating. The lighter phase, or raffinate, represents the high quality lubricating oil and contains some 10% of solvent. The extract, or heavy phase, contains 90% of the solvent and the undesirable lubricating oil components which readily carbonize or oxidize in an engine.

The two phases are separated and then stripped of their respective solvent content. A high degree of solvent removal is necessary for three reasons: (1) Solvent in the refined lubricant would lower the flash and fire point as well as viscosity and lubricating qualities, and, in addition, decompose under engine conditions with probable production of corrosive organic acids. (2) In the extract the same would be true were it to be used as a low-grade lubricant or in grease manufacture, and the reduced flash point would make it less desirable as fuel oil. (3) The solvent costs approximately $1 per gal. in quantity purchases, requiring complete stripping for operating economy.

The last operation is purely a solvent reclaiming process, in that it must be freed of water extracted from the oil during treating and condensed from steam while stripping furfural from the two oil phases.

TABLE 1—Solvent Processing of Neutral Oil

	Charge	Raffinate	Extract
Gravity, °API	26.5	31.2	11.0
Flash, ° F.	410	420	400
Fire, ° F.	470	475	460
Viscosity SSU @ 100° F.	219.3	180.0	2226
Viscosity SSU @ 210° F.	46.2	45.0	61.85
Viscosity Index	76.2	97.0	—34.9
Color, ASTM	3½	1½	2+ (½ mm)
Pour, ASTM, ° F.	5	10	5
Conradson Carbon Res., %	0.02	0.008	0.51
Neutralization No.	0.02	0.002	0.02
Yield, %	100.0	80.0	20.0
Treating Tower, Top, ° F.		230	
Treating Tower, Bottom, ° F.		160	
Solvent Dosage, %		200	
Ratio Recycle Extract Charge Oil		0.35	
Tower Pressure, psig		75	

Three Stocks Processed

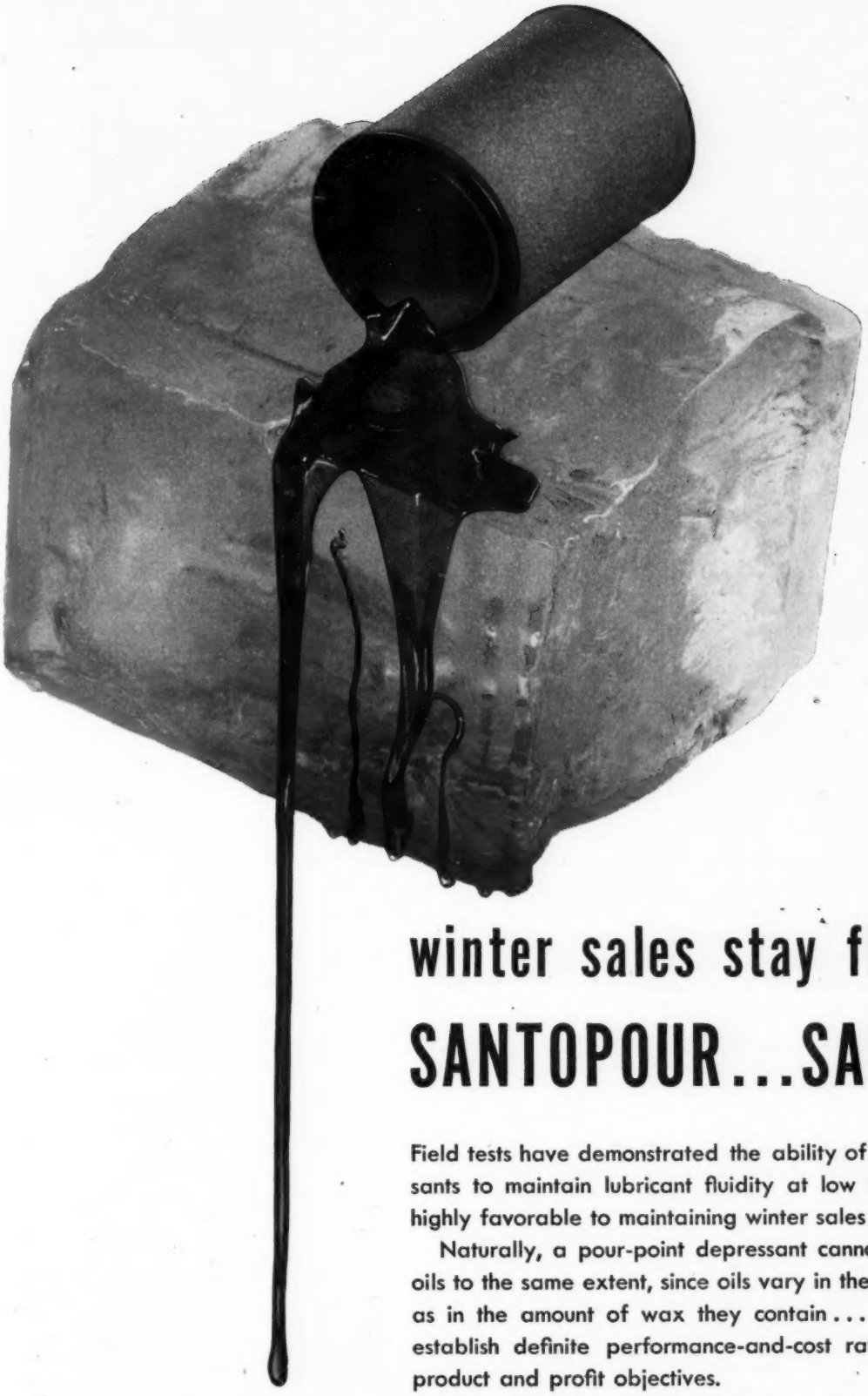
During the three weeks of break-in operation three types of charge oil were processed to provide a quick appraisal of the unit. On each stock the charge rate was increased to 115% of design capacity to determine the limiting throughput factor. During change-over from one stock to another, operating conditions were maintained to continue producing a 95-viscosity index intermediate oil which was run to a special tank.

When raffinate from each new charge stock met specifications, it was switched to regular rundown tanks for processing through percolation filters. Material in the special rundown tanks will be used for blending purposes. Eventual disposition of the extract has not been revealed, although CRA officials say little of it will be sold as fuel oil.

Data from processing two stocks in the new unit are presented in Tables 1 and 2, a neutral oil and bright stock respectively.

Inspection of these tables reveals that in each case a minimum of 95 V. I. was obtained, together with a sharp drop in carbon residue. It will be noted also that viscosity of the extracted material greatly exceeds either that of the raffinate, or refined oil, and the raw charge material.

In the case of the bright stock, Table 2, little color improvement was obtained for the reason that the raw charge was produced by chilling a naphtha blend of residual stock to well below 0° F. and sulfuric acid treating for simultaneous



winter sales stay fluid, too

SANTOPOUR...SANTOPOUR B

Field tests have demonstrated the ability of Monsanto pour-point depressants to maintain lubricant fluidity at low temperatures — a fact that is highly favorable to maintaining winter sales as well.

Naturally, a pour-point depressant cannot reduce the pour test of all oils to the same extent, since oils vary in their general composition as well as in the amount of wax they contain . . . Also, it is often desirable to establish definite performance-and-cost ratios that will meet specified product and profit objectives.

If you are interested in specific recommendations that will result in optimum performance in your base oil, dollars-and-cents blending economies, and pour-point stability of oils in winter storage — contact the nearest Monsanto District Sales Office, or write MONSANTO CHEMICAL COMPANY, Petroleum Chemicals Department, 1700 S. Second Street, St. Louis 4, Missouri. District Sales Offices: New York, Chicago, Cincinnati, Boston, Charlotte, Detroit, Birmingham, Houston, Los Angeles, San Francisco, Seattle. In Canada: Monsanto (Canada) Limited, Montreal.

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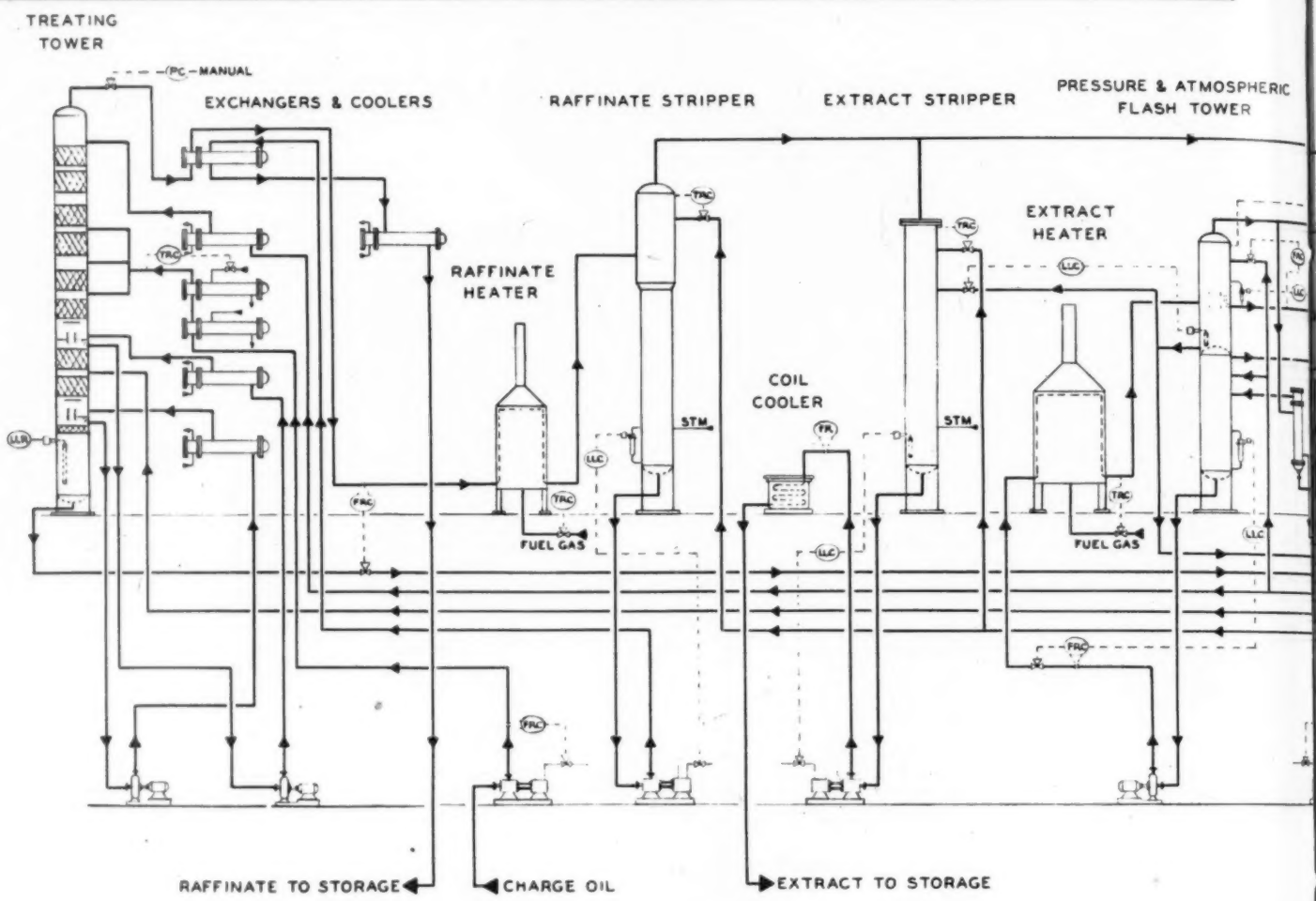


dewaxing and deasphalting. This was followed by clay contacting, filtering and reduction to a predetermined viscosity. In effect the stock already was refined by the previous standards at the plant.

The neutral oil in Table 1, on the other hand, shows an improvement of two NPA numbers as well as high V. I. and low carbon residue. It was prepared by chilling and pressing a light wax distillate followed by reduction to sufficient viscosity to allow for further viscosity reduction during treating.

Operating cost data from the present runs are considered too meager and inaccurate for publication. However, solvent losses have been accurately determined to be 42 gal. per day or 0.06% daily loss, based on hourly circulation of solvent and solvent storage gages before and after the 3-weeks run. It is expected this figure will be decreased as operations progress, although it is considered unusually low for a start-up.

TABLE 2—Solvent Processing of Bright Stock

	Charge	Raffinate	Extract
Gravity, °API	23.6	26.5	14.7
Flash, ° F.	540	555	500
Fire, ° F.	615	625	570
Viscosity SSU @ 100° F.	3508	2524	13,430
Viscosity SSU @ 210° F.	164.5	151.8	225.4
Viscosity Index	81.6	95.9	—5.34
Color, ASTM	6+	6—	Green
Pour, ASTM, ° F.	15	20	25
Conradson Carbon Res., %	1.47	0.70	3.09
Neutralization No.	0.015	0.005	....
Yield, %	100.0	80.5	19.5
Treating Tower, Top, ° F.		290	
Treating Tower, Bottom, ° F.		225	
Solvent Dosage, %		450	
Ratio Recycle Extract Charge Oil		0.50	
Tower Pressure, psig		75	

For better understanding of the inovations of the new furfural unit, flow sequence will be described first, followed by comment on technological departures from earlier units.

Raw charge at 75 psi enters the upper portion of the treating tower after preheating by successive exchange with exhaust and live steam to the desired treating temperature, which varies with the stock. Solvent, either from the bottom of the "A" fractionator or from storage, is admitted at the top and is also cooled or preheated, as may be required, to the desired treating temperatures. The raw oil stream is admitted through one of three nozzles to assure mixing and the temperature gradient is controlled by intercooler streams as shown in Fig. 1, a simplified flow-sheet. To obtain maximum yield of raffinate, an extract recycle stream is returned to the tower.

Raffinate mix leaves the treating tower at its top, picking up heat in exchange with finished raffinate and enters the raffinate heater. Outlet temperature is controlled to that necessary for flashing off solvent in the extract stripper. Steam also is admitted to the bottom of the stripper. Stripper overhead is both solvent and steam, passing to a condenser which also condenses overhead from the extract stripper, all condensed material dropping to the container labeled "CBM receiver" in Fig. 1.

Raffinate stripper bottoms is finished raffinate—refined oil—which exchanges heat with raffinate mix, thence flows through a cooler to storage.

The extract mix, upon leaving the bottom of the treating tower, is directed by tower pressure to an exchanger system which provides the necessary heat for primary solvent flash at atmospheric pressure. It cools the extract recycle returning to the treating tower, condenses the atmospheric column overhead vapor and the pressure flash tower overhead vapor before entering the atmospheric tower, where approximately 40% of the solvent content is removed overhead.

The dry vapor overhead from this tower, after condensation in the exchange condenser, enter the "A" fractionator at the boiling point. The extract mix, now less rich solvent, flows to the extract heater.

Outlet temperature at the extract heater is carefully controlled, with great attention given to prevent exceeding 450° F., above which furfural begins to decompose into organic acids. The Petro-

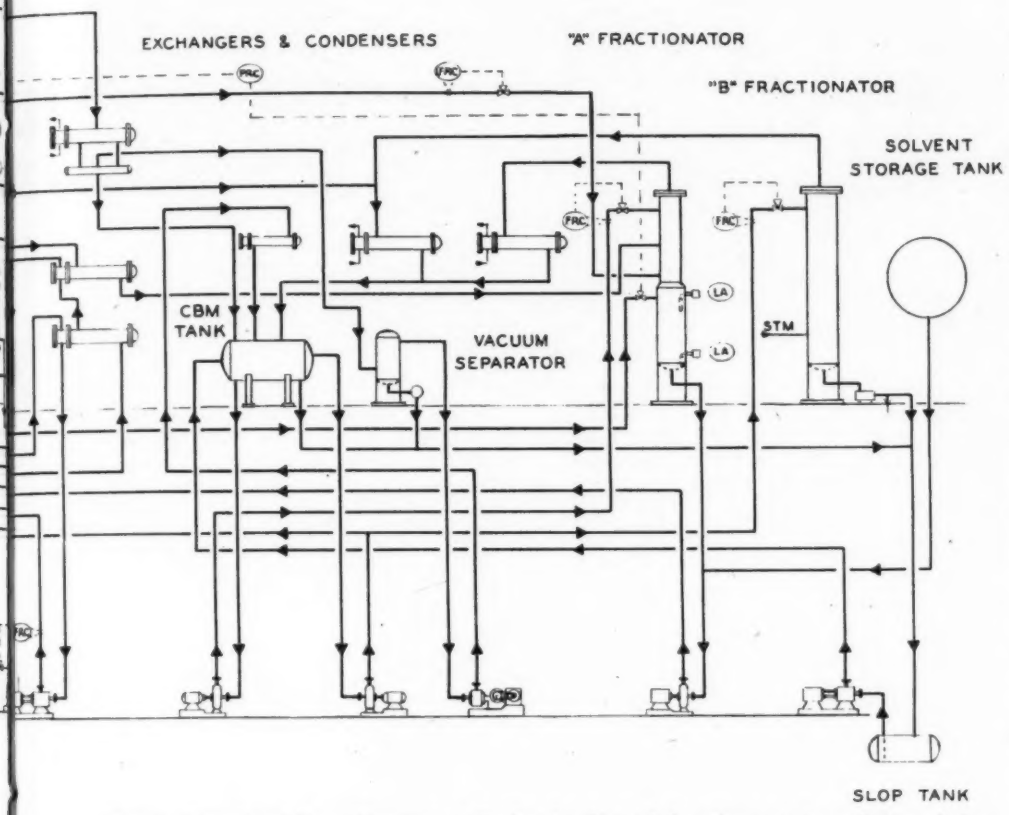


Fig. 1—Simplified flow diagram of Furfural solvent lube plant at the refinery of the Cooperative Refinery Assn., Coffeyville, Kans.

chem heater is of the vertical, all-radiant tube type, as is the raffinate heater, and feed is split equally to dual coils.

This feature permits a low pressure drop across the tubes as well as low pressure operation in the vaporizer section. Maximum vaporization at low pressure is thus obtained at minimum temperature, which is credited by plant operators with savings in solvent make-up requirements because of less solvent decomposition. This, in effect, in turn means decreased formation of organic acids and, in fact, has rendered apparently unnecessary provisions in other equipment intended to remove corrosive decomposition products.

Heated raffinate then enters a pressure flash vessel operating under 30 psi where dry furfural is taken overhead, condensed, and enters the "A" fractionator. For reasons to be explained later, a vapor slip-stream is taken ahead of the overhead condenser, passing direct to the "A" fractionator to provide reboil heat.

Bottom product of the pressure flash vessel contains approximately 5% of solvent, and is charged to a low pressure stripper under level control. A portion of this product is returned by pump to the treating tower as extract recycle.

The stripper is operated similarly to the raffinate stripper, heat in entering product being sufficient to vaporize remaining furfural with the aid of steam. Overhead steam and solvent are lead to the common condenser previously mentioned and thence to the "CBM receiver." Stripped extract is cooled and pumped to storage.

In earlier plants, reflux to all recovery system towers was dry furfural. That which served the two strippers eventually reached the "CBM receiver" before final drying. The unit at the Coffeyville plant, however, utilizes a slip-stream (containing about 93% water) from the "B" fractionator charge pump. Due to the difference in latent heats of furfural and water, the volume required for reflux duty is reduced 75%, effectively reducing the volume of furfural to be dried.

The reader undoubtedly has noted that dry furfural streams in the recovery system are returned to the "A" fractionator; the wet streams to the "CBM receiver." Furfural and water form a constant boiling point mixture whose boiling point is below that of either component and contains about 35 wt.-% furfural. This requires an elaborate system to recover solvent from the water.

Hence the receiver for this mixture of constant-boiling point liquids derives its name, shortened to "CBM." Due to solubilities of water in furfural and furfural in water, two well-defined phases exist in the CBM receiver. Contingent on temperature the layers vary in composition but for average operating conditions (110° F.) the upper layer contains 8.5% by weight furfural in water; the lower 5.5% water in furfural.

The bottom CBM layer is charged to the top of the "A" fractionator. This column serves two purposes: (1) the enlarged bottom section is in reality a solvent surge vessel supplying dry solvent to the treater and (2) the top section which removes overhead a constant boiling mixture containing some furfural and all the water in the "A" fractionator.

Dry furfural from the pressure flash column enters the storage section directly. Wet furfural from the CBM tank enters the top deck of the fractionating section. The fourth tray from the top charges furfural from the atmospheric flash column previously mentioned, which contains a small amount of water picked up from the raw oil charge. The vapor slip-stream from the pressure flash vapor line, mentioned earlier, is admitted at the bottom of the fractionating section where it supplies reboil heat for fractionation by simultaneously vaporizing the constant boiling mixture and condensing furfural which drops into the storage section. CBM overhead is condensed and returned to the CBM tank where the original equilibria are again set up.

The top CBM tank layer is "B" fractionator charge. Steam is admitted at the bottom. Overhead is still another constant boiling mixture, condensed and returned to the CBM tank, and the bulk of the water in the charge drops to the bottom of the tower for discharge to the sewer. (In the event tower operation is upset, leaving appreciable solvent in the water, the bottoms stream is directed to a slop tank for eventual re-working.)

New Features Employed

Earlier furfural units employed surge tanks for raffinate and extract mixes from the treating tower which was operated at low pressure. On the new Coffeyville plant, these surge tanks with their attendant controls and pumps have been eliminated. The tower is operated under a pressure of 75 psig, which is sufficient to deliver both the extract and the raffinate mix to the succeeding steps in the operation.

The treating tower is somewhat taller than required for a unit of this capacity. The top section offers sufficient surge capacity for the raffinate mix. The section between furfural and oil inlets is the extraction section, wherein the solvent, at a temperature sufficiently high to provide some solvent power in addition to its selectivity, removes the undersirable components as well as considerable "good" oil. At the same time, additional "good" oil—raffinate—is moving upward from the disengaging section so that eventual equilibrium is reached and

treated raffinate enters the raffinate mix surge to the tower outlet.

Below the oil inlet is a "disengaging" section. Due to intercooler circulation, the tower temperature is being gradually reduced and the furfural, while retaining its selectivity, loses its solvent power for "good" oil. Thus raffinate is released to proceed up the column into the treating section. This process is further advanced by the introduction of extract recycle below the oil inlet. This material, by increasing the concentration of extract in the solvent, "salts out" the raffinate oil. The bottom of the tower serves as surge capacity to the extract system.

Unique Instrumentation

Control of flows to and from the treating tower requires unique instrumentation.

Pressure on the treating tower system is controlled by a remote-operated, manually-set motor valve located in the raffinate mix outlet line from the top of the tower. The manual control is placed on the central control board (Fig. 2). The valve is, in effect, a fixed orifice in the discharge line from the tower with the pressure drop through the orifice holding the desired pressure on the treating system. The size of the orifice can be changed as required for different charge rates and different solvent ratios. Since the oil and solvent charge rates are regulated by rate of flow controllers, the input and output flows are uniform. Once the manually set pressure control valve is positioned for one set of operating conditions, no further change in the setting is required unless charge rates, degree of extraction, or type of charge stock are varied.

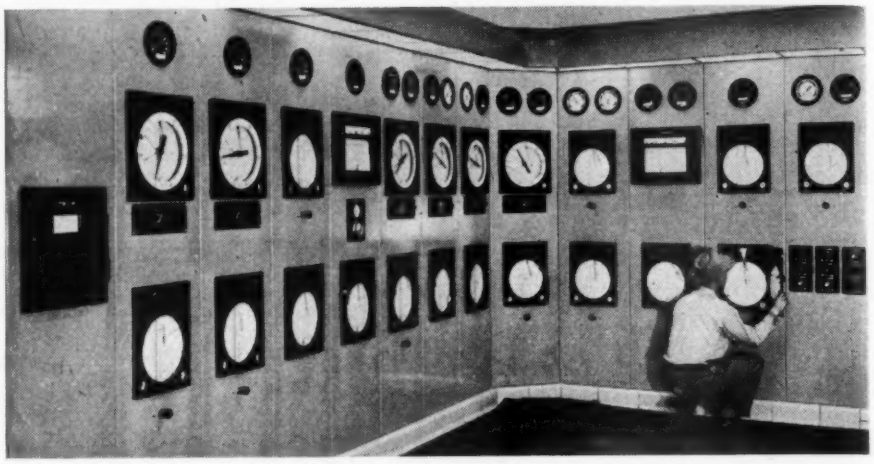


Fig. 2—General view of solvent unit control panel. Top row of instruments (Brown) are pressure gages and level indicators, temperature recorders and controllers occupy middle row and flow recorder-controllers at the bottom. Instrument at far left is a multipoint potentiometer for general process temeratures, control in middle of fifth panel from left manually sets treating tower pressure

The logical method of discharging the extract mix from the bottom of the treating tower would appear to be by interfacial level control, but the interface between the two layers is not clearly defined, necessitating another approach. The orifice of a conventional rate of flow controller was placed in the raffinate mix outlet line from the top of the treating tower, and the controlled motor valve was placed in the extract outlet line. The motor valve is reverse acting so a trend to an increasing flow of raffinate mix opens the motor valve in the extract mix line to return the raffinate mix flow rate to the control setting. Since, for any given set of operating conditions, the volumetric ratio of raffinate mix to extract mix is constant, the rates of flow of both mixtures are brought under control at uniform rates.

The approximate position of the interface level is recorded on the main control board by remote transmission from a long-range displacement-type float located in the base section of the treating tower. In addition "clear vision" type gauge glasses were provided to aid in determining the interface level. These have been so successful during operation that it has been unnecessary to use the sample draw-off method. Radical changes in the position of the interface indicate the necessity for changing the ratio of raffinate mix to extract mix withdrawal which can be accomplished by resetting the flow controller described above.

Treating Tower Temperature Control

Control of temperature gradient through the treating tower is of utmost importance and offers several interesting instrumentation features. Solvent for recirculation is obtained from the surge capacity in the bottom of "A" fractionator and must be cooled to required temperature. This is accomplished in a shell-and-tube cooler through which water circulates at a constant rate.

A temperature controller actuates two motor valves—one located in a cooler by-pass and the other in the cooler inlet line. The thermal element is located downstream to the junction of the by-pass and the cooler outlet. A trend to temperature increase above the control point decreases the valve opening in the by-pass and increases the flow to the cooler. Since the pressure drop through the cooler is relatively small, it was felt that the by-pass control would not be

(*Continued on page* 557)

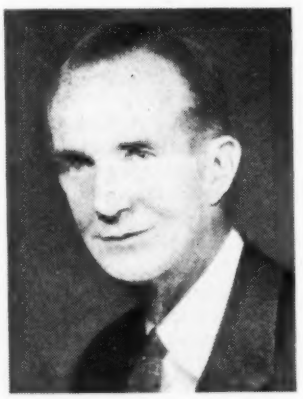
Louis C. Brown, Chief Refinery Engineer for Cooperative Refinery Association's three refineries, joined C.R.A. in 1944 as process engineer over HF alkylation and isomerization units, assuming his present position in 1946.

He holds a B.S. degree from Notre Dame (1934) and formerly was technical assistant, operations department, National Refining Co., Findlay, O.

Mr. Brown

Claud F. Tears is vice president of Process Engineers, Inc., Dallas, designer and principal contractor for the C.R.A.'s furfural lube plant. A Cornell graduate of 1917, he started with the Lummus Co. and has been with Universal Oil Products Co., M. W. Kellogg Co., and Alco Products, Inc.

In the refinery field he has had experience with The Texas Co., Continental Oil Co., and Bradford-Penn Refining Corp. before forming Process Engineers. In the chemical field his experience includes design and operation of the Bishop, Texas, plant of Celanese Corp. of America.



Mr. Tears

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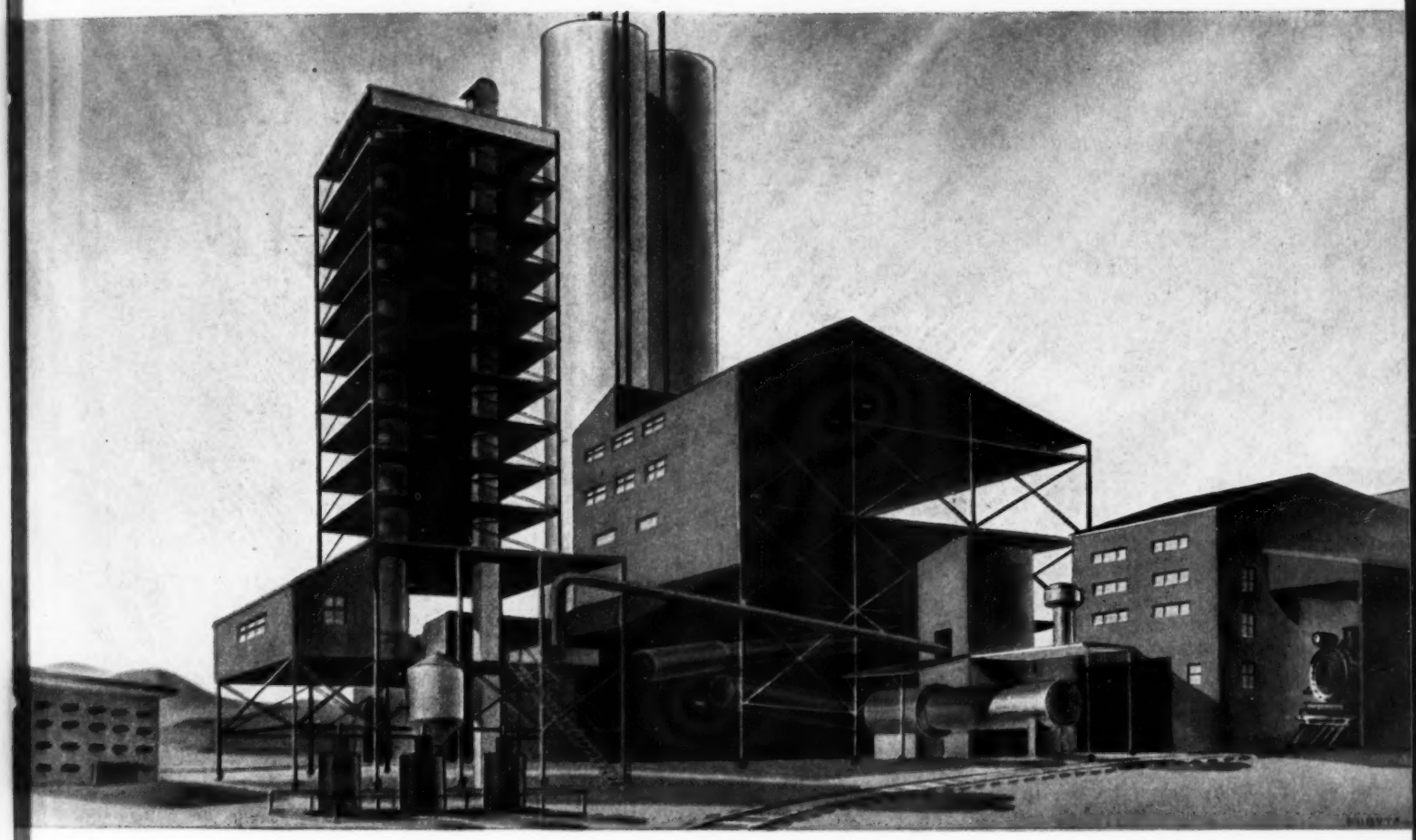

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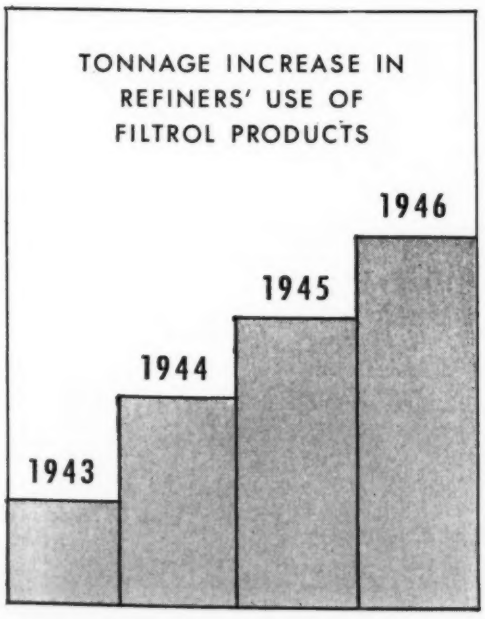

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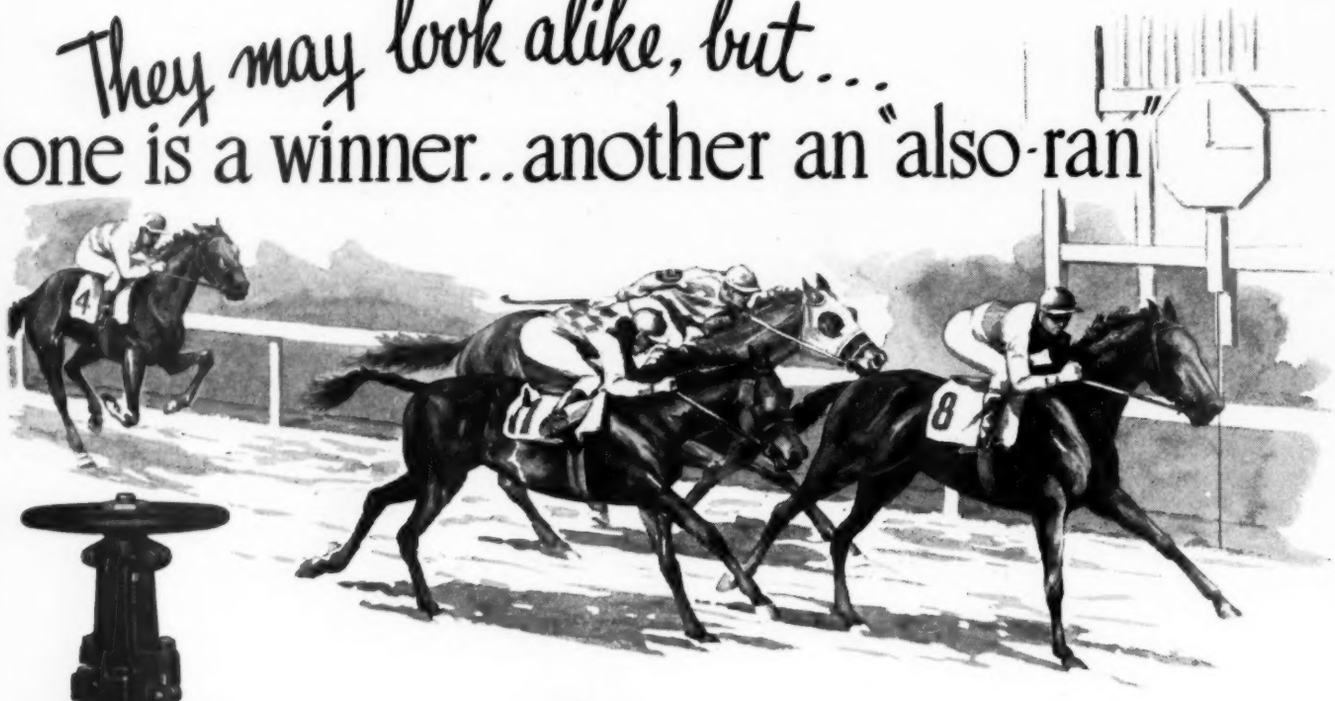

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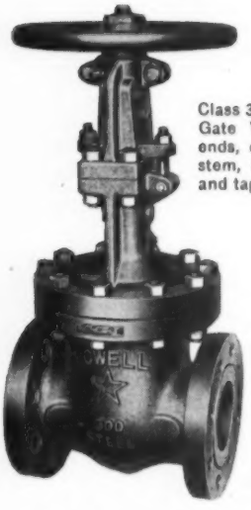

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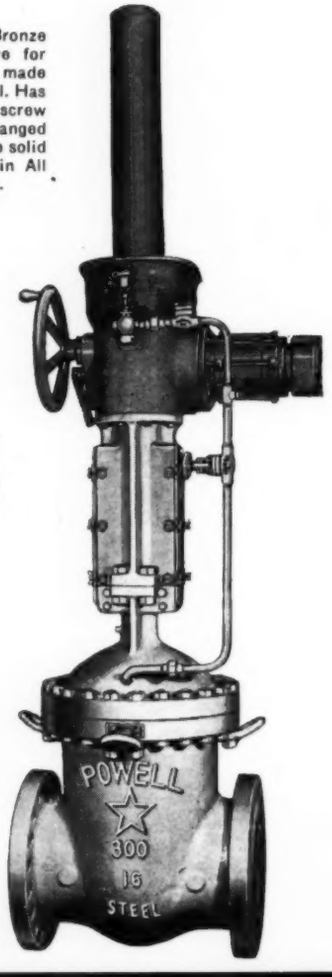

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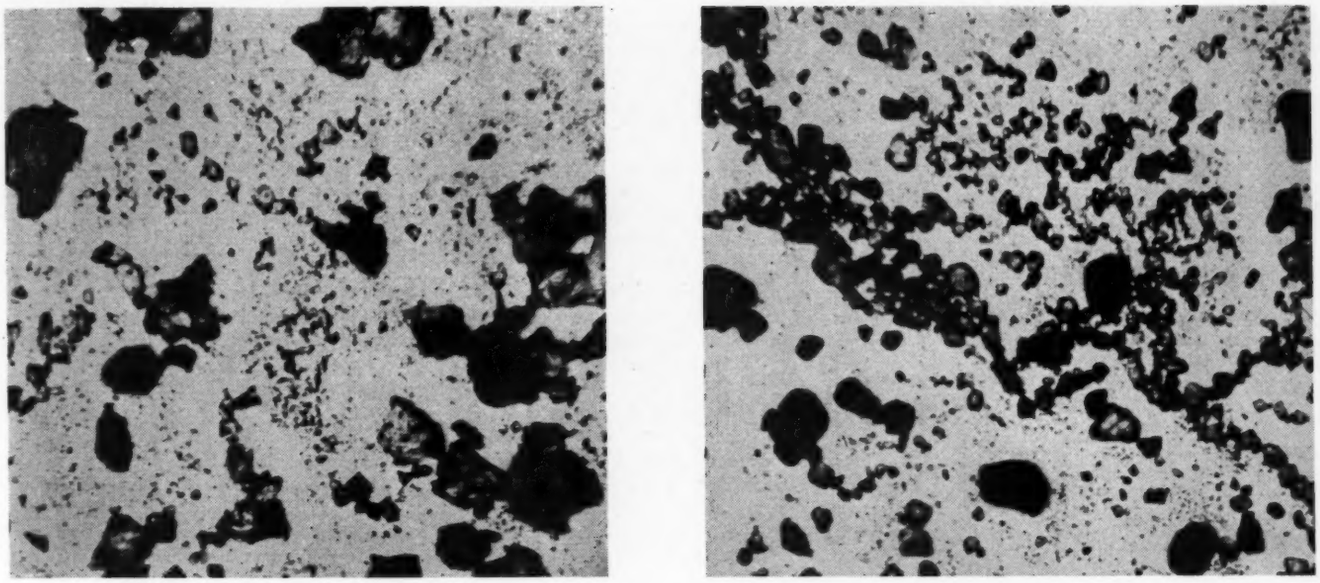


Fig. 1—Photomicrographs of fresh (left) and used (right) synthetic Fluid cracking catalyst

Particle Size Distribution Of Cracking Catalysts

By GLENN M. WEBB, Director,
Physics Division, Riverside Laboratories,
Universal Oil Products Co.

Mechanical screening and liquid sedimentation, the latter particularly for sub-sieve particles, have been developed into reliable methods for obtaining data on the particle size distribution of the silica-alumina catalyst used in commercial Fluid catalytic cracking operations. The techniques of the two methods are described. Experimental work included a comparison of results obtained by each method. Taking into account prescribed precautions, it has been found possible to obtain good agreement between particle sizes determined by mechanical screening and liquid sedimentation.

WITH the advent of the Fluid catalytic cracking process[12] a need arose for a reliable method of measuring the particle size distribution of the catalyst employed. This catalyst is a silica-alumina composite that has a large specific surface and a highly porous structure. It is usually ground mechanically in a ball mill or the equivalent so that is passes through a 30-mesh or finer sieve.

When the catalyst is fresh it is irregular in shape; after use in a commercial gas oil catalytic cracking unit, the particles are rounded off somewhat. Photomicrographs of typical fresh and used catalysts are shown in Fig: 1.

In view of the wide range in size of particles present in this type of catalyst, it was apparent at the outset that both mechanical screening and sedimentation or elutriation methods would probably have to be used. A preliminary review of the relative merits of liquid sedimentation and air elutriation revealed[1] that air elutriation methods[8, 9, 10] suffer from several drawbacks. Notably, there is some question as to the applicability of Stokes' law under the turbulent conditions that exist in the settling chambers and also that attrition of the particles occurs during the test.

As a result of these observations, attention was concentrated on developing a liquid sedimentation method for analyzing the sub-sieve particles. The obvious advantages of this method are: (a) attrition cannot occur; (b) a continuous particle size distribution curve is obtained; (c) the apparatus is small, compact, and easy to build and operate; and (d) the test conditions are relatively easily reproduced over long periods of time. The principal disadvantage is that agglomeration or flocculation of the particles may occur.

Mechanical Screening

The mechanical screen analysis of the Fluid cracking catalyst is straightforward, and in general follows the ASTM procedure[3] except in one respect. The synthetic cracking catalyst, when dry, is an excellent electrical insulator, and carries such a large electrical charge that small particles will not pass through holes even twice their diameter. It has been found convenient to humidify the catalyst to increase its electrical conductivity so that the charge can be rapidly dissipated. Standard practice at the Riverside laboratories is to store the catalyst overnight in a desiccator partially filled with a 30% sulfuric acid solution. The amount of water adsorbed varies with the origin of the catalyst, and with its history, such as time of use in a commercial plant, but is usually in the neighborhood of 3-6%.

Liquid Sedimentation

The principle of the liquid sedimentation method for determining particle size distributions is well known and involves the assumption that particles fall through a viscous medium at a constant

velocity, v, given by Stokes' law, as follows:

$$v = \frac{2g}{9\eta}(\rho_1 - \rho_2)r^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where

v = velocity of fall (cm./sec.)
g = acceleration of gravity (980 cm./sec.^{2})
η = absolute viscosity of the liquid (poises)
ρ_1 = density of particle (gms./ml.)
ρ_2 = density of liquid (gms./ml.)
r = radius of particle (cm.)

It is also assumed that the particles are smooth and spherical, uniformly distributed throughout the liquid at the instant settling commences and that the concentration is sufficiently low that the particles do not interfere. These conditions are seldom encountered. Arnold and others have shown[2, 11] that Stokes' law is valid up to a maximum particle size, given by

$$D_c^2 = \frac{21.6\eta^2}{\rho_2(\rho_1 - \rho_2)g} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where D_c is the critical maximum particle diameter (in cm.).

This relationship requires that the Reynolds number $\rho_2(dv/\eta)$ (d being the particle diameter) be less than 1.2. Other workers, for example Dorr and Roberts[4], have concluded that Stokes' law is valid for Reynolds numbers below 1.0; this corresponds to a reduction of the constant in Equation 2 from 21.6 to 18.0. For liquids in common use, D_c as defined by Equation 2 has the following values for fresh catalyst:

Liquid	D_c (in Microns)
Methyl alcohol	111
Water	154
Isopropyl alcohol	280
Ethylene glycol	1140

Thus, it appears that Stokes' law can be safely used in studying the particle sizes of catalysts usually encountered in practice.

Procedure

The procedure adopted for determining particle size distributions by sedimentation techniques is similar to that described by Martin[6]. It involves suspending a small amount (about 1%) of the catalyst in a liquid and noting the variation in weight of a plummet as settling of the powder proceeds. From the resulting curve the particle size distribution is calculated using Oden's method of tangential intercepts. It is not considered necessary to report here the details of the method, since they are well covered in Martin's paper. However, two items will be discussed, having to do with the choice of the sedimenting liquid, and the determination of the proper particle density, ρ_1, that should be substituted in Stokes' law.

1. Sedimenting Liquids.—Water and ethylene glycol have been the two liquids used in most of our work up to recent months. Ethylene glycol is suitable for the analysis of samples containing particles larger than about 40 microns, and water for particles smaller than about 75 microns. However, when particles smaller than about 25 microns are present, agglomeration or flocculation occurs in the presence of both water and ethylene glycol.

The method of testing for flocculation is an indirect one. One of the easiest methods, although not the most sensitive, is to suspend a given weight of catalyst in several different liquids and note the settled volume of the powder. As a general rule the settled volume increases with extent of flocculation. Also, the better the dispersion the harder is the compacted mass. Finally, the clarity of the supernatant liquid also provides a measure of the extent of dispersion:

A liquid which causes much flocculation (or disperses the powder poorly) becomes clear a few minutes after being allowed to stand; while a liquid which does not produce flocculation remains cloudy for several weeks. The best dispersing liquids are some of the alcohols (isopropyl alcohol being a good one) and acetone. The poorest one tried to date is carbon tetrachloride. Water and ethylene glycol are far better than carbon tetrachloride but not quite so good as acetone or the alcohols.

Another method of estimating the dispersing characteristics of various liquids which is much better than the above-described one, but much slower, is to obtain an actual particle size distribution by sedimenting the powder in the chosen liquid. In this case, the measure of dispersion is the actual amount of material in, say, the 0-10 micron fraction. The greater the quantity of this small sized material found, the better is the dispersion. The dispersing properties of water, isopropyl alcohol, and carbon tetrachloride have been checked by this method and the same conclusions noted above have been reached, namely, that the alcohol disperses the powder to the greatest extent and the carbon tetrachloride, to the least.

In view of these observations, isopropyl alcohol and methanol have been adopted as the preferred liquids for analyzing powders that have material of interest in the region below about 40 microns. In samples that have particles larger than 40 microns, flocculation is not bothersome, and almost any liquid that has desirable viscosity and density characteristics may be used; the one employed at Riverside is ethylene glycol.

2. Particle Density.—The quantities appearing in Equation 1 are all easily measured except for the density of the particle. The correct particle density that should be used depends on the density of the material comprising the particle, the porosity of the particle, and the density of the liquid. From these quantities the effective or apparent particle density can be calculated. The density of the liquid may be assumed known. The density of the material comprising catalysts can be measured in a variety of ways; in actually using the sedimentation method, the catalyst is put into the liquid held at 20° C. and agitated thoroughly. By using this method, a material density of 2.34 gms./ml. for Fluid cracking catalyst (alumina content of 10-12%) for quite a number of liquids including ethylene glycol, water, acetone and isopropyl alcohol is obtained. This value is very close to that obtained by the helium displacement method.

The porosity of the catalyst particle may also be measured in a variety of ways; the one used in the present work involved determining the total pore volume by adsorption of nitrogen at the temperature of liquid nitrogen.

Experimental Work

A. Effect of Humidification on Screen Analysis

To illustrate the effect of catalyst moisture content on the observed screen analysis, two catalysts (No. 1 & No. 2) of similar composition were sieved dry after being moistened. The catalysts were dried at 1000° F. and after being cooled in a desiccator portions were screened; other portions of the calcined catalysts were stored overnight in a desiccator charged with 30% sulfuric acid solution and then screened.

B. Effect of Sedimentation Liquid on Dispersion of Powder

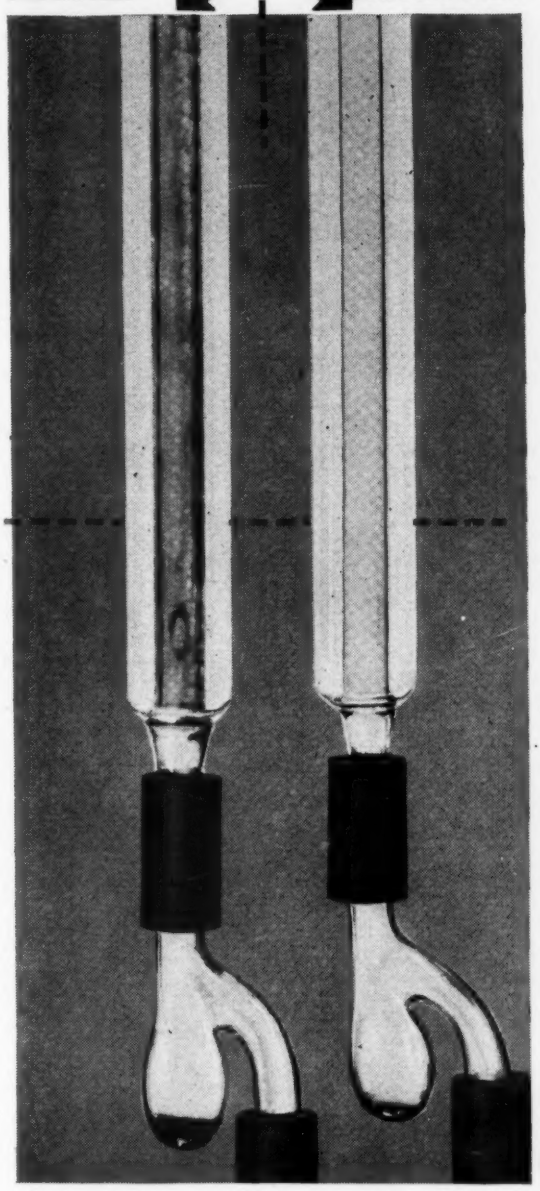
To determine the effect of the type of liquid used for the sedimentation tests, a few experiments have been made comparing directly the behavior of water and isopropyl alcohol. These experiments have all been made on one sample of catalyst, No. 3. The catalyst as received was settled (two determinations) in isopropyl alcohol; it was also calcined for two hours at 1000° F. to dehydrate it and was then settled once in water and twice in isopropyl alcohol. Since a direct determination of the pore volume of this catalyst either before or after calcination was not available, it was necessary to assume a pore volume of 0.50 cc./gm., which is typical of fresh catalyst.

C. Comparison of Screening and Sedimentation Results

1. Tests on Discrete Mesh Size Fraction.—Three fresh cracking catalysts were mechanically screened, using U. S. sieve series screens, into 80-100, 100-150, 150-200, and 200-300 mesh fractions. The screened portions were then run in the liquid sedimentation test unit, using ethylene glycol as the sedimenting liquid.

Particle size distributions were obtained from the sedimentation data, us-

These 2 tubes tell the story...



(Vertical glass manifolds, operated at 150 deg. F. mixture temperature, show effect of PARADYNE FUEL IMPROVER on deposits.)

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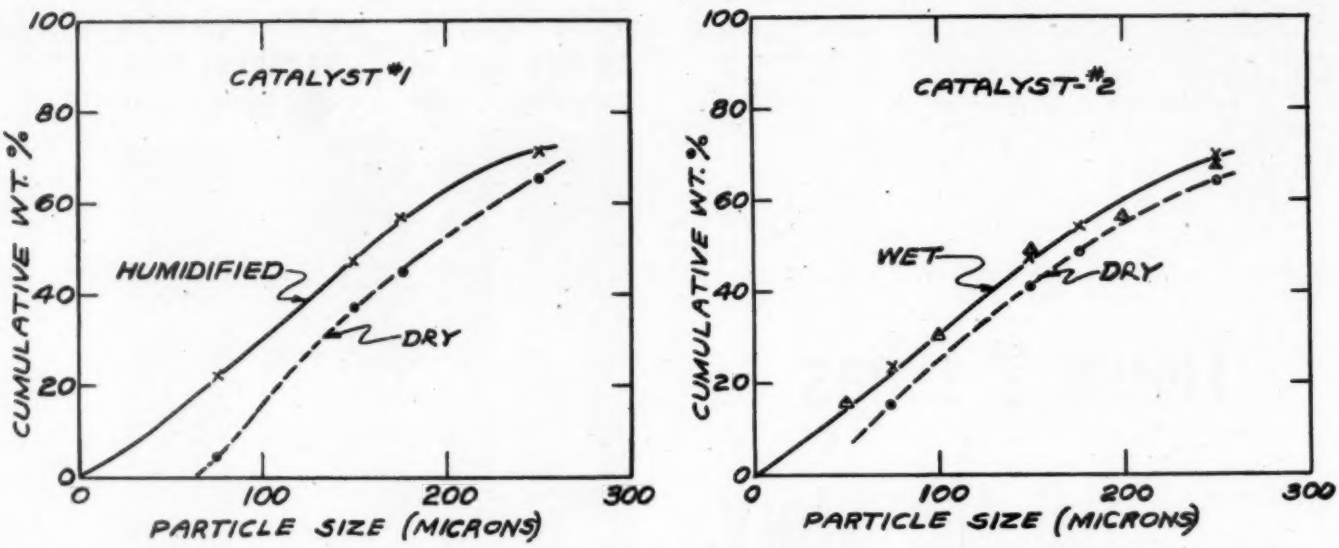

Fig. 2—Effect of humidification on screen analyses of two catalysts. The letters o and x refer to screen analysis made with the powder dry and moistened respectively. Sedimentation data available for Test 2 (right) is shown by Δ

ing standard procedures. The densities of the particles were calculated from the material densities of the solids, their porosities, and the density of the ethylene glycol. These data are given in Table 1. The pore volumes recorded in Table 1 were obtained from low temperature nitrogen adsorption data[5].

TABLE 1—Densities of Discrete Mesh Size Particles

Catalyst Powder No.	True Material Density gm./cc.	Pore Volume cc./gm.	Density of Ethylene Glycol gm./cc.	Calculated Apparent Density of Particles gm./cc.
4	2.34	0.40	1.11	1.74
5	2.34	0.42	1.11	1.72
6	2.34	0.78	1.11	1.55

In order to calculate the diameter of a particle, Stokes' law is rearranged as follows:

$$D^2=\frac{18\eta}{g(\rho_1-\rho_2)}\times\frac{S\times10^8}{T\times60} \quad \ldots\ldots\ldots(3)$$

where D is the diameter of the particle in microns and S is the distance fallen in T minutes. For the particular apparatus used at Riverside, S. the length of the plummet, is 8.03 cm. The viscosity, η, of the ethylene glycol is 0.206 poises. Using these values, Equation 3 takes the following form for the three catalysts discussed above:

Catalyst 4 ..... $D = 284T^{-\frac{1}{2}}$
Catalyst 5 ..... $D = 289T^{-\frac{1}{2}}$
Catalyst 6 ..... $D = 339T^{-\frac{1}{2}}$

Since the experimental technique employed yields a relationship between the per cent of material sedimented as a function of the time, the equation above may be used to obtain the desired relationship between the per cent of material sedimented and the particle diameter.

2. Tests on Entire Samples.—Numerous tests have been made on entire samples of catalyst, both fresh and after extended use in commercial cracking units. Typical of the catalysts studied are those described in Table 2; these were all sedimented in isopropyl alcohol (density = 0.79 gms./ml.). The densities of these catalysts, saturated with isopropyl alcohol at 20° C., were determined in the same way as was done for the catalysts mentioned in the preceding section.

TABLE 2—Densities of Full Range Size Particles

Catalyst	True Material Density (gram/ml.)	Pore Volume (ml./gram)	Apparent Density of Particle Saturated with Alcohol (gram/ml.)
Fresh— 7	2.34	0.62	1.42
— 8	2.34	0.56	1.46
— 9	2.34	0.52	1.49
—10	2.34	0.44	1.55
Used —11	2.34	0.42	1.57
—12	2.34	0.41	1.58
—13	2.34	0.28	1.72
—14	2.34	0.27	1.73
—15	2.34	0.27	1.73
—16	2.34	0.27	1.73
—17	2.34	0.20	1.84

Particle size distributions were calculated in the same way as was done for the fresh catalysts of discrete mesh sizes described above.

The 11 samples were also analyzed by the mechanical screening method described earlier.

Discussion of Results

A. Effect of Humidification on Screen Analyses

The data obtained in these tests are displayed graphically in Fig. 2 and summarized in Table 3.

Test 1 of Fig. 2 shows a direct comparison of a screening test made on dry and wet powder (no sedimentation analysis is available on this identical sample). The relative positions of the dry and wet curves have been frequently observed in the past; the dry catalyst shows an apparently larger size than the wet because of its high electrical charge. This charge effectively prevents the particles from passing through a hole considerably larger than the particle itself.

Test 2 of Fig. 2 is a similar plot for another catalyst except that in this case sedimentation data are available. As in Test 1, the dry catalyst shows less small material by screen analysis than the wet catalyst does. It is to be pointed out that the sedimentation data fall very well on the curve obtained on the wet catalyst.

B. Effect of Sedimentation Liquid

The results obtained in the settling of a fresh commercial catalyst in water and isopropyl alcohol are given in Table 4. Fig. 3 contains a plot of Tests 2 and 3, showing a comparison of particle size distribution obtained with water and isopropyl alcohol.

This plot, as well as the data in the table, brings out clearly the phenomenon of flocculation referred to earlier. The isopropyl alcohol more completely disperses the powder, causing an increase in the measured amount of fines present.

C. Comparison of Screening and Sedimentation Data

1. Tests on Discrete Mesh Fractions.—The data obtained on the several samples of catalyst that were first screened and then sedimented are given in Table 5. These results are very interesting from several points of view. When the data are plotted on probability graph paper (size vs. cumulative wt.-% straight lines result in every case, which means that the distribution of particle sizes follows the so-called normal or Gaussian distribution law. One set of the data for catalyst No. 4 has been graphed and appears in Fig. 4.

The most significant feature of the data may be seen from the summary presented in Table 6, wherein the average particle sizes of the different catalyst are given as determined by both screening and sedimentation.

The average size of the material in

a certain mesh size range has been assumed to be the arithmetic average of the sizes of the openings in the screens. For the screens used in the present work, these openings are: 80 mesh = 177μ; 100 mesh = 149μ; 150 mesh = 105μ; 200 mesh = 74μ, and 300 mesh = 48μ.

From the sedimentation data, the average size has been taken to be the point at which 50% of the material has sedimented. Also included in the table is the percentage of material larger than, within, and smaller than the sizes as defined by the screens. These values were read from curves similar to Fig. 4. All of the data of Table 6 show that there is very good agreement between the average size as determined from the sedimentation and screening results. In general, there is a tendency for the sedimentation data to give a slightly larger average size than the screening tests; also, the average amount of material found by sedimentation larger than the largest screen is 24% while the amount smaller than the smallest screen is only 12%.

This suggests that the openings in the screens may be larger than they are for new screens. This explanation should not be taken too literally for there are other uncertainties in both methods of analysis that could easily account for the observed differences.

This agreement between sedimentation and mechanical screening data confirms data obtained by Rittenhouse[7], and would indicate that the flatness ratio described by Rittenhouse, namely, the ratio of the short diameter to the intermediate diameter of the grains is close to 1 for synthetic ground cracking catalyst.

2. Tests on Entire Samples.—The data on mechanical screening and liquid sedimentation obtained on the entire powders were compared by determining the average particle size by both methods. In the case of the screen data this was done by simply averaging the openings in the two adjacent screens. To obtain this figure for the sedimentation tests, the data were plotted on rectangular paper (wt.-% of material smaller than a given size versus the size) and reading from the graph the average, or most probable size, which was taken to be that size corresponding to the 50% point.

The average particle sizes of all of the catalysts studied are plotted in Fig. 5. This curve shows the relation between the data on mechanical screening and liquid sedimentation. The circles refer to fresh catalyst and the crosses, to used catalyst. The solid line represents the line calculated from the data by least squares and has the form

$$d_{screen} = 1.026 d_{sed.}$$

The dotted line represents the ideal case where

$$d_{screen} = d_{sed.}$$

Virtually all of the average sizes determined by liquid sedimentation are larger than those obtained from the mechanical screening tests. This may be due to a variety of causes, but at least one contributing factor is the fact that the particles are not spherical and therefore can pass through a square opening the side of which is shorter than the length of the particle. Hence the correct size to ascribe to a square opening is somewhere between the length of the side and the diagonal.

The correction factors for fresh and used catalyst are probably not the same; present data are too meager to permit these to be estimated at this time. On the basis of all of the available data, the sedimentation and screening data agree quite well if the screen sizes are multiplied by 1.10. It is interesting to note that this factor is fairly close to the ratio of the diameter of a circle and the side of a square having the same areas (ratio = 1.13).

The comparisons shown in the table between fresh and used catalyst reveal in a qualitative sense that the sedimentation method can be used for determining the particle size distributions of used catalyst. Used catalyst differs in one very important respect from fresh catalyst; it possesses a distribution on particle density as well as in particle size.

TABLE 3—Effect of Humidification on Screen Analysis

Catalyst No.	Sieve Analysis: Size Microns	Mesh Size	Dried at 1000° F. wt. %	Humidified wt. %	Sedimentation Analysis: Size Microns	wt. %
1	74 thru	200	4.7	22.5	50	Not Available
	149 thru	100	37.5	47.5	100	
	177 thru	80	45.3	57.0	150	
	250 thru	60	65.2	71.5	200	
	420 thru	40	97.8	95.0	250	
2	74 thru	200	15.6	23.6	50	15.3
	149 thru	100	40.7	47.9	100	30.5
	177 thru	80	48.5	54.4	150	48.8
	250 thru	60	64.0	69.3	200	56.3
	420 thru	40	97.6	98.2	250	68.2

TABLE 4—Particle Size Analysis of Catalyst No. 3

Test No. 1 Size Range Microns	Test No. 2 Water Calcined 1000° F.	Test No. 3 Isopropyl Calcined 1000° F.	Test No. 4 Alcohol As Received	Test No. 5 Alcohol As Received
0-10	1.0	7.0	15.0	13.0
10-20	16.0	11.5	9.0	11.5
20-30	9.8	10.5	8.0	9.5
30-40	11.2	10.0	9.2	9.5
40-50	10.5	9.3	9.6	8.3

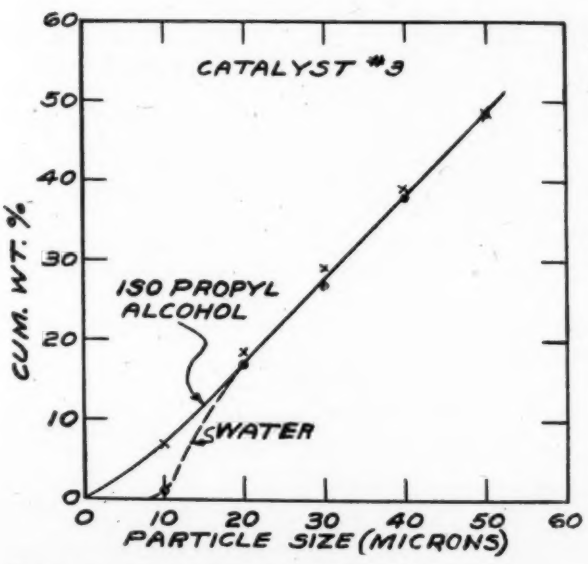

Fig. 3 (Left)—Comparison of water and isopropyl alcohol as sedimenting liquids

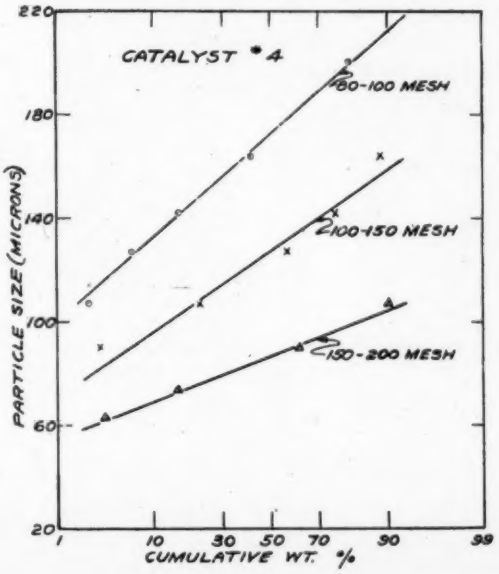

Fig. 4 (Right)—Sedimentation analysis of discrete mesh sized portions

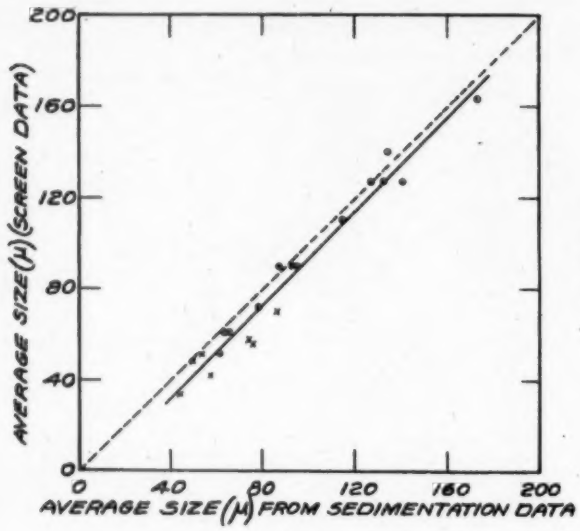

Fig. 5—Comparison of average particle sizes as determined by liquid sedimentation and mechanical screening

This means that the average particle density calculated from the pore volume may be in error in certain particle size regions, and hence may lead to distortion of the particle size distribution curve.

Application to Routine Control Work

The methods described above have been used for some time in these laboratories for the purpose of running acceptance tests on fluid cracking catalyst made to Universal Oil Products Co.'s specifications by the American Cyanamid Co. and by the Chicago Chemical Co. These specifications limit both the amount of coarse material (on 100 mesh sieve) and of extreme fines (below 10 microns). The routine acceptance tests involve both the mechanical screening and liquid sedimentation procedure. The former is run exactly as described above; the latter is also made in the manner described, except that an average value of the pore volume is used. The reasons for this are that the experimental determination of the pore volume by low temperature nitrogen adsorption techniques is lengthy, and also, that the individual determination of the pore volume of each test catalyst has been found to be unnecessary because its value is quite constant.

Experience has shown that the pore volume of the average sample of fresh catalyst is close to 0.50 cc./gm. This value is used for all fresh catalysts. The actual sedimentation is made with methyl alcohol; this liquid was chosen because it disperses the catalyst very completely, and also for the pragmatic reason that a complete sedimentation curve, covering the 0-60 micron region, can be obtained in a short time, approximately thirty minutes.

Summary

The main feature of the mechanical screening method of measuring particle size is the humidification of the powder prior to screening. This is necessary because the catalyst, when dry, is a good insulator and carries such a large electrical charge that a particle will not pass through a hole even twice its diameter. Moistening of the powder permits rapid dissipation of the electrical charge.

The important particulars involved in obtaining reliable data on the sub-sieve portions by liquid sedimentation are choice of the proper sedimenting liquid and use of the correct particle density for substitution in Stokes' law. The liquid must be so chosen that good dispersion of the powder is obtained; experience has shown that isopropyl alcohol is one of the better liquids in this respect, water and ethylene glycol being fair, and carbon tetrachloride very poor. The correct particle density is the density of the particle saturated with the liquid in which the sedimentation is to be made. This is calculated from the true material density of the particle, the density of the liquid, and the pore volume of the porous solid, determined by low temperature nitrogen adsorption.

Taking into account all of these precautions, it has been found possible to obtain good agreement between particle sizes of Fluid cracking catalysts determined by mechanical screening and by liquid sedimentation methods.

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TABLE 5—Comparison of Screen and Sedimentation Data

Catalyst 4				Catalyst 5				Catalyst 6			
	Mesh Range				Mesh Range				Mesh Range		
Size μ	80-100	100-150	150-200	Size μ	100-150	150-200	200-300	Size μ	100-150	150-200	200-300
	Wt. % Smaller Than Stated Size				Wt. % Smaller Than Stated Size				Wt. % Smaller Than Stated Size		
284	95.0			289				339			
201	80.5	94.8		205	94.8						
164	41.3	88.5		166	83.5						
142	15.9	76.0		145	61.7			170			
127	6.6	57.3	(99)	129	38.1			151	81.9		
107	2.3	21.9	90.2	109	11.5	79.4		128	48.5		
90		3.1	60.0	91.6		42.0		117	12.1	89.9	
73.6			15.9	74.8		9.3	73.6	87.6	1.4	53.1	(97)
63.2			3.7	64.2		2.3	46.0	75.2		4.9	88.0
51.8				52.7		0.4	15.0	61.7			45.9
44.8				45.7			4.0	53.5			22.3
40.3								47.7			7.1

TABLE 6—Comparison of Screening and Sedimentation Data

Average Size (μ)	Catalyst 4			Catalyst 5			Catalyst 6		
	80-100	100-150	150-200	100-150	150-200	200-300	100-150	150-200	200-300
By screen	163	127	90	127	90	61	127	90	61
By sedimentation	173	127	87	140	95	66	132	93	63
% > mesh range	44	19	10	36	27	26	18	22	13
% in mesh range	33	63	73	55	64	68	75	68	80
% < mesh range	23	18	17	9	9	6	7	10	7

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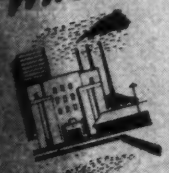

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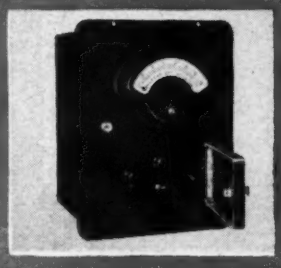

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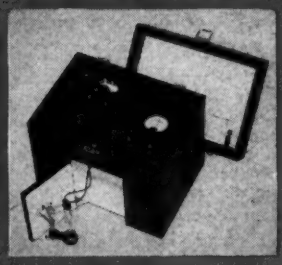

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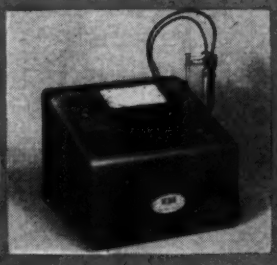

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Fundamental Requirements for Arrangement Of Drains and Vents in Processing Units

Systems for Disposal of Gas and Oil in Emergencies Or During Routine Maintenance Must Be Efficient and Simple so as to Reduce Chances for Operating Errors

Acknowledgment

This presentation is based on a paper, "Fundamental Requirements for Safe Arrangements of Drains and Vents," by J. H. Johnsen, an assistant head engineer, Engineering Dept., Whiting (Ind.) refinery, Standard Oil Co. (Indiana), and persented at the joint technical meeting of Indiana Standard and subsidiaries at French Lick, May 5-9.

SAFE and efficient operation of modern petroleum processing units demands soundly arranged drain and vent systems. Oil and gas can then be quickly disposed of in an emergency as well as during periods of general shutdown or for repairs on specific equipment.

In general, emergency disposal of hot oil is accomplished by releasing into a system where the oil is quenched with water. The resultant liquid is released into the refinery sewer where it finds its way into the waste disposal system, and the vapors are vented through a stack.

Gaseous and liquid hydrocarbons of higher vapor pressures are disposed of under emergency conditions by releasing into a blowdown drum. Vapor and gas from this drum are vented into a flare stack and burned, and the liquid is pumped to tankage. Relief valves discharging liquid are usually vented into these blowdown systems, and relief valves discharging vapor are vented to the atmosphere at safe elevations.

Systems for ordinary drainage during normal operation, or where needed during emergencies, are of two types: pressure and nonpressure. The first is a closed system from pressure source to disposal point. It includes drainage from such points as pumps, dry drums, sample connections, and pocketed sections of lines. Nonpressure drains are from open funnels at telltales, pump packing glands, open sample connections, and the like.

Both types of drains are usually routed to separate underground sumps. For hot oils this may be the base of the blowdown stack. For cold oils it may be a sewer box compartment with a sump pump for recovering oil and sending it to slop tankage.

Venting facilities are also provided to safely dispose of noxious hydrocarbon vapors by venting either into the process gas lines to the flare stack, or through an eductor discharging into a sump vent stack. Packing-gland vapor leakage at pumps and compressors is removed through ducts connected to an exhaust fan discharging at a safe location.

While the incorporation of vent and drain facilities into a refinery design is a "must", it is imperative that the facilities be kept simple. Complicated drain and vent systems would increase chances for operating errors.

The following discussion is meant primarily to illustrate the fundamental requirements for emergency and normal operating use of the various types of drain and vent systems, rather than to furnish a complete description of the necessary facilities for any particular unit.

Drain System for Normal Operation of Catalytic Cracking Units

THE numerals and letters in Fig. 1 correspond to those in the outlined procedure given below.

A. Furnaces:

(1) AMO (air motor operated) valve in blowdown line from convection section (may also be used in blowdown line from furnace inlet).

(2) Manually controlled valve for drain or blowdown from radiant section transfer line.

(3) AMO valves for admitting fire steam.

(4) Furnace inlet line.

(5) Furnace outlet line.

All AMO valves operated from a central control station, preferably on an inside wall of main control room. AMO valves can best withstand high temperature fire conditions, and would not be incapacitated by possible power failure. They are provided with insulated housings.

B. Towers:

(6) AMO valve in blowdown line from pump suction line at tower bottom. It should be as close to suction line as possible to avoid long dead ends which may plug upstream of the valve.

C. Towers and Drums:

(7) Relief valve which vents vapor to atmosphere at a safe elevation. Snuffing-stream connection permits dilution of vapors to prevent ignition at vent.

If it is desirable to discharge vapor into a closed system instead of the atmosphere, rather large discharge lines are needed to minimize back pressure. If dual relief valves are used, interlocked or 3-way shutoff valves are required in discharge lines to allow removal of either relief valve.

D. Liquid-filled Vessels:

(8) Relief valve connected to blowdown stack for release of liquid, as for example, on the slurry settler.

E. Exchangers:

(9) Relief valve.

(10) Collecting drum. (Used where there is a large number of exchangers).

F. Blowdown Stack:

(11) AMO valves in fire water lines to quench nozzles.

(12) Manual valves (usually located in water pump room) to supply fire water to internal and external spray rings in upper section of stack.

Water and quenched oil are separated from steam and oil vapors in the base of the blowdown stack. If lower disengaging velocities are wanted, a quench and separating drum is also provided and is vented back into the blowdown stack.

Water and oil flow from the stack through a sewer gas trap and then to the sewer. Upstream side of trap is vented back to the stack.

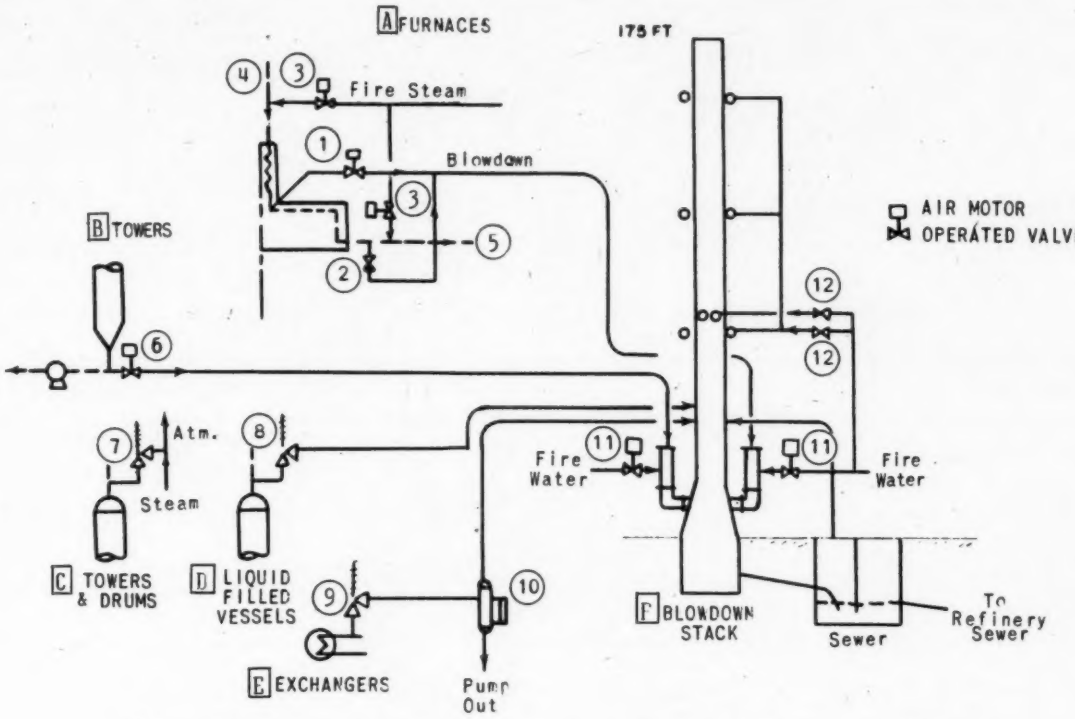

Fig. 1—Facilities for emergency disposal of hot oil on typical catalytic cracking unit

Blowdown stack is located close to furnaces and hot towers to shorten blowdown lines and minimize fire hazard to other equipment. On large units, blowdown drainage is preferably run separately to refinery sewer rather than with other drainage from the unit, because of relatively large volume to be handled, and because possible foaming would tend to plug any common line.

Because of large volume of oil and water handled, it is usually impractical to install facilities for keeping blowdown oil out of refinery sewer system. It can be recovered at the regular separators.

For delayed coking units, some deviations from the above system are necessary since the blowdown system is also used in steaming and washing coke drums preparatory to decoking. On each unit, a second blowdown drum, vented to the blowdown stack, is provided for steaming the coke drums when removing the unit from service.

Emergency Disposal of Cold Oil and Gas from Refinery Units

COLD oil at low vapor pressures (about 12 lbs. RVP or less) is usually disposed of by pumping to suitable storage tank. In some cases, it is first pumped through a gas-release tower outside of the unit. This tower is vented to a flare stack or into the refinery gas-collecting system.

For higher vapor pressure cold oils, a system is used such as shown in Fig. 2, for blowdown diposal on vapor recovery and polymerization units. The numerals and letters in the figure correspond to those in the text below.

A. Blowdown Drum:

Receives oil from various parts of the unit. It is provided with an external steam heating coil (not shown) to aid in vaporizing the light fractions and reducing the vapor pressure so that the liquid can be pumped to field storage.

B. Flare Stack:

Receives vapors from blowdown drum. It is 200 ft. high, 24 in. in diameter, reduced to 16 in. at the top. A constantly burning pilot flame furnishes ignition for the vapors leaving the top. The top swaged section, 9 ft. long, is made of 18-8 chrome-nickel steel to withstand the high temperatures. Flame arrestor located near the top consists of 4 layers of 40-mesh wire screen, and is electrically heated to prevent plugging with ice.

To avoid back-flash, a small amount of off-gas from the unit is bled into the stack continuously through a restriction orifice (not shown). Some spark plug arrangement is also usually installed for reignition of the flare in case the pilot flame goes out.

Both drum and stack should be located a safe distance from any unit—about 300 ft. or more, if space is available.

Low nickel alloy steel pipe is recommended for the blowdown header and the line between the unit and the flare system in cases where low temperature materials such as propane are encountered.

C. Drum Blowdown:

Arrangement for disposing of oil in towers and drums, which, though cooled, would still have too high vapor pressure to handle in tankage outside the unit. On the Whiting vapor recovery unit, for example, there are three such drums—the absorber feed accumulator, lean oil reflux drum and depropanizer reflux drum.

(1) Electric motor operated valves on blowdown lines from these drums. Located at high points in the line so downstream side will drain into the blowdown header.

(2) By-pass valve.

(3) Restriction orifice.

The orifice is sized so that blowdown will not exceed the flare-burning capacity of the stack.

The blowdown header is also used as an emergency outlet for off-gas streams leaving the unit in case of a stoppage of the off-gas line. A manually operated gate valve (not shown) is provided for this purpose.

D. Normal Make Gas:

(4) Control valve and orifice.

This valving arrangement is provided in the make-gas line to the suction of

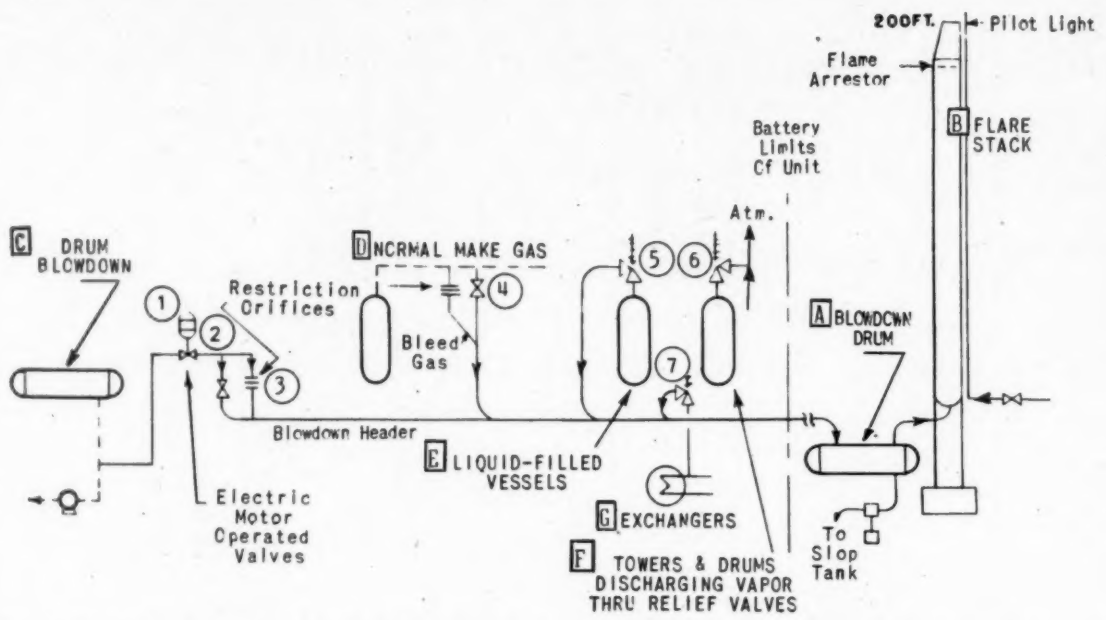

Fig. 2—Typical blowdown system for disposing of light materials on vapor recovery and polymerization units

the gas compressors on catalytic cracking units. It is set to open at a predetermined pressure, a few pounds above the normal gas-compressor suction pressure, thus automatically releasing make-gas to the flare in case of compressor failure. This is very important because of the low operating pressure (about 5 psig at the compressor suction) of catalytic units and their dependence on proper pressure differentials across the slide valves.

E. Liquid-filled Vessels:

(5) Relief valve to blowdown header (similar to the arrangement for liquid-filled vessels containing hot oils as shown at D-8 in Fig. 1, under the general heading, "Drain Systems for Normal Operation of Catalytic Cracking Units."

F. Towers and Drums:

(6) Relief valves connected to vent to atmosphere where discharge is vapor, similar to set-up for towers and drums as shown in Fig. 1.

G. Exchangers:

(7) Relief valve.

Where feasible, exchanger relief-valve vents are piped into the blowdown system, as shown in Fig. 2. However, since the blowdown lines are designed to drain the blowdown drum, the line is usually rather high. In order to prevent pocketing of the relief-valve discharges, the relief valves must be located above the blowdown line.

This may necessitate rather long lines between the exchangers and relief valves, as well as additional platforming for easy access. Consequently, in some cases exchanger relief valves are piped to the closed drain system through an underground header.

Emergency Disposal of Hot Oil from Catalytic Cracking Units

THE purpose of drain, vent, and pumpout systems on process units is for safe disposal of oil and gas in lines and equipment as needed during normal operation and during starting-up and shutting-down periods, and to keep as much of the oil and gas as possible out of the refinery sewer system. Fig. 3 shows diagrammatically a drain system for a catalytic cracking unit. The numerals and letters correspond to those in the text below.

I. Cold Oil Pressure Drains

A. Cold Oil Pumps:

For draining when shutting down, bleeding off the discharge for pump priming, bleeding off the suction to eliminate water during start-up, etc.

B. Gas Compressor:

(1) Drain valve at compressor suction.

(2) Drain valve at compressor interstage.

(3) Drain valve at compressor discharge.

C. Fuel gas and other similar dry drums:

(4) Drain valve. (Used only where there are large quantities of oil to handle.)

D. Cooling-tower water-and-oil disengaging drum:

(5) Interface-level control valve. In case of oil leakage into the water in shell-and-tube coolers, the oil and gas is accumulated in this drum and drawn off automatically.

E. Sample Point:

(6) Valve connections for flushing out the sampling system before drawing off a sample.

F. Other Drains:

(7) Drain lines from relief-valve atmospheric vents to drain any liquid leakage through the relief valves.

G. Separating sump:

(8) Vent to blowdown stack.

(9) Sump pump.

Cold pressure drains are discharged into the sump. Vapors are vented to stack, and sump pump transfers oil slop to tankage.

II. Hot Oil Pressure Drains

H. Hot Oil pumps:

For draining for the same reasons as given under "A. Cold oil pumps."

I. Hot Oil Coolers:

(10) Relief valve on water side of hot oil coolers where oil-side pressure is higher than water-side pressure. In case of tube failure, the relief valve would discharge hot oil.

J. Washing Drains:

(11) Drain valves.

K. Furnaces:

(12) Drain valves.

Although these are not actually hot-oil drains, some may be present in the wash water, and there is also too much water for the cold pressure drain sump to handle. It is therefore run into the hot

pressure drain header so as to disengage any oil vapor in the base of the blowdown stack before release to the sewer.

L. Blowdown stack:

Receives discharge from hot oil pump. Where this is not convenient, a separate sump and water-quench system (not shown) is provided.

III. Nonpressure Drains

Nonpressure drains are collected in open funnels and run into a vented collecting sump, as shown at **M** in Fig. 3. They normally include drains from bearing brackets (packing leakage) on pumps, from oil sample points, as shown at **E**, from telltales at various points, from atmospheric equipment, from sample-room sinks, etc.

Hot oil nonpressure drainage is usually not of sufficient quantity to warrant a separate system, and all nonpressure drainage is handled in a common header. If properly sealed in an adequately vented collecting sump, the nonpressure drainage can be run into the same sump as is used for cold pressure drains. However, because of the possibility of excessive pressures developing in the cold pressure lines through the release of large quantities of light oil, it is preferable to collect nonpressure drainage in a separate sump as shown in Fig. 3.

Running traps are provided in nonpressure drain lines leaving buildings, as indicated in the nonpressure drain header from the cold- and hot-oil pumps in the figure, to keep gas from other sources from backing up into the buildings.

Both the pressure and nonpressure drain sumps are provided with sealed emergency overflow pipes to the refinery sewer system in case of sump pump failures.

IV. Oil-Bearing Water

N. Process-water draw-off:

(13) Interface-level control valve.

The process-water drain routes oil-bearing water to a section of the sewer box downstream of the nonpressure and pressure drain sumps but upstream of the outlet section of the box.

A steam line is provided to heat this section of the sewer box so as to vaporize as much light oil as possible before the water is released to the refinery sewer.

On some units, process water may be piped to the closed drain sump for recovering large quantities of oil by means of a conventional skimming baffle (not shown).

V. Miscellaneous Drainage

O. Surface drain:

For non-oil-bearing waters. These are carried along with steam trap condensate to the sewer box.

P. Furnace deck drain:

To handle hot-oil spillage from furnace in case of tube failures. They are

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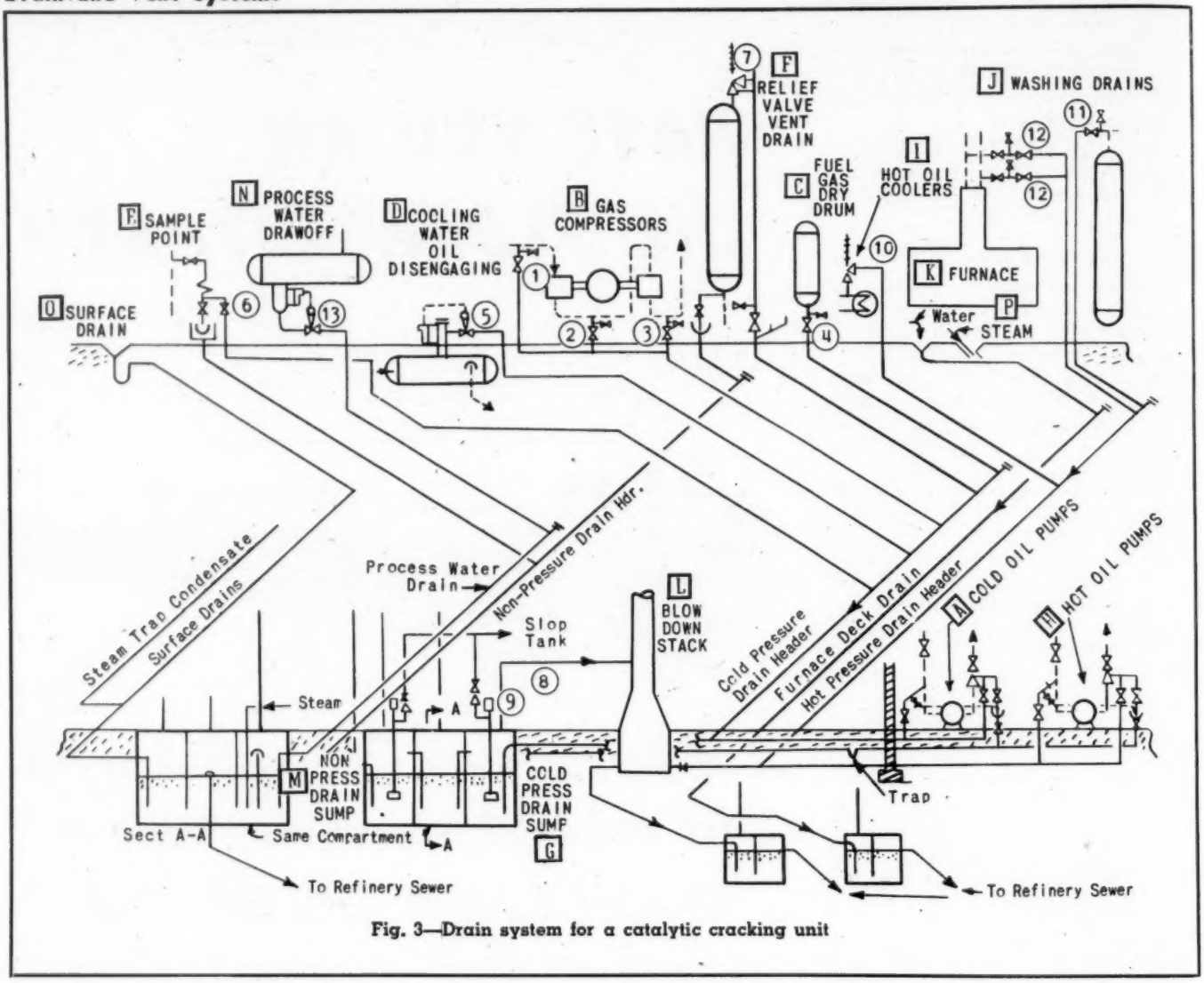

Fig. 3—Drain system for a catalytic cracking unit

provided with steam to facilitate drainage, and water to seal the drain and insure against gas back-up. Drainage passes through a separate gas trap and on into refinery sewer.

In some cases, these drains are piped into the base of the blowdown stack; but, where there is not sufficient fall in the drain to the stack, foaming may build up enough static head to back oil out of these drains. The system shown in Fig. 3 is therefore preferred.

Drain System for Normal Operation of Vapor Recovery Units

UNITS processing light oils at higher pressures, such as vapor recovery units, require only a cold-oil pressure drain system. Numerals and letters in Fig. 4 correspond to those in the text below.

A. Closed drain sump:

Receives cold-oil pressure drains from four main headers. It includes a 100-ft. vent pipe.

(1) Hydrocarbon drains. This is not combined with any other streams entering the drain sump because of the possibility that very low temperatures from vaporization of light liquid hydrocarbons might freeze the moisture present in the other streams.

(2) Drains from relief-valve atmospheric vents. This header is sealed under the liquid level in the sump and is run separately so that any vapors from the other headers will not back out through the relief-valve vents. The valves in this system are left open so that any liquid leakage through relief valves vented to the atmosphere will drain into the sump.

(3) Reboiler steam condensate. This keeps flashed steam from entering other systems and avoids back pressure due to vaporization of light materials if mixed with the hot condensate. Most of the steam condensate from reboilers is piped to a steam flash drum where it is recovered. This connection is for emergency use, and for diverting enough of the condensate into the sump to aid in vaporizing light hydrocarbons before release to the refinery sewer. The header is sealed under the water level in the sump.

(4) Process-water and wash-water draw-off. This is also sealed under the sump water level to avoid gas back-up.

Owing to the more volatile materials processed in these units as compared to the catalytic cracking units, it is usually the practice not to provide a pump in the closed drain sump. A large portion of the oil entering the sump is vaporized, and the sump is primarily for disengaging vapor.

B. Open drain sump:

Handles nonpressure drains. It is equipped with a pump for transfer of drains to a slop tank, and an emergency overflow leading to the sewer gas trap.

C. Sewer Gas Trap:

Collects material from closed drain sump, open drain sump, as well as miscellaneous surface drainage and steam trap condensate.

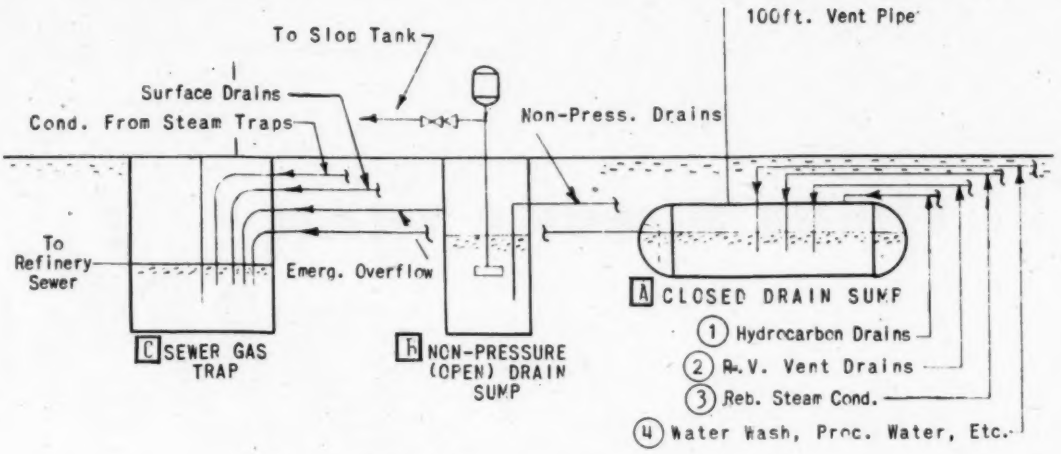

Fig. 4—Vapor Recovery unit drain system

Vent System for Shutting Down of Vapor Recovery Units

A TYPICAL venting system for handling volatile materials during shutting down on a vapor recovery unit is shown in Fig. 5.

Facilities are provided to depressure vessels, exchangers and pumps by venting into the wet-gas system to reduce to about 0.5 psig. On units where no wet-gas system is available, the equipment can be depressured by releasing into the flare stack. A steam eductor is also provided for pulling down to a vacuum if desired.

A spool, which is removed during normal pump operation, is provided between block valves in each pump-depressuring connection so as to avoid inadvertent excessive venting from the pumps.

Vessels are first depressured into the fuel-gas system down to about 25 psig, avoiding excessive venting to the wet-gas system. This connection to the fuel-gas system also serves for backing in fuel gas after steaming the vessels during start-up. In cases where gas at higher than 25 psig is available, connections are also provided for pressuring vessels with this gas.

Pumpout Systems

Pumpout systems are provided to handle relatively large quantities of oil which, when cooled, are of sufficiently low vapor pressure to be pumped to refinery tankage. In some instances, as on the bottom of towers, connections are provided to both the pumpout and drain systems. It is usually preferable to use the pumpout system for all except emergency conditions when the pumpout system may be inaccessible or too slow.

Connections to the pumpout system are usually provided from vessels and the oil sides of exchangers, and in some cases from large trapped lines. Two or more separate pumpout systems may be provided, depending on the materials to be handled. For example, on catalytic cracking units, light and heavy oils are handled in separate pumpout lines manifolded to a common pump; a separate slurry drain header, pump, and cooler box are provided which can be cross-connected with the heavy-oil pumpout system. When required, connections are provided so that the pumpout pump can be used to fill the unit with oil from an outside source for circulation during start-up.

In pilot-plant and laboratory-scale equipment the smaller quantities of material involved usually necessitate some departures from the blowdown and drain and vent facilities described. However, the principles involved should be followed whenever required to provide a safe installation. Generally, relief valves and venting facilities are provided for pilot plants, but liquid disposal is accomplished by draining into barrels after the equipment is cool.

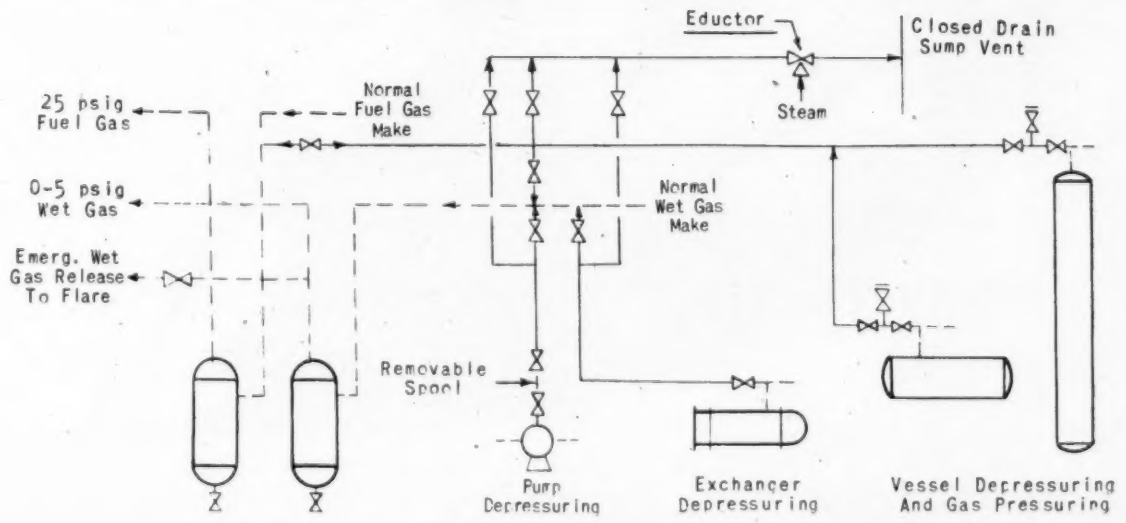

Fig. 5—Vapor recovery unit depressuring and pressuring systems

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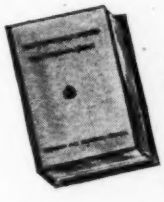

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Salvaging Commercial Minerals From Oil Field Brines

By ROBERT H. DOTT, Director,
Oklahoma Geological Survey

NATURAL brine is widely distributed in buried sedimentary rocks, in the cavities and smaller pore spaces. It is often encountered in the course of drilling for petroleum oil and gas.

The composition is dependent, of course, upon the nature of the mineral material with which the brine is in contact or through which it has passed. In the majority of cases the predominant component is sodium chloride (common salt) with more or less calcium, magnesium, potassium, strontium, and barium salts present as chloride, sulfate, and bromide.

The brine encountered in the oil fields of Oklahoma is of this type. In three instances Oklahoma brine has been used as raw material for commercial production of salt. The fact that large quantities of brine are brought to the surface in the production of petroleum and that the brine must be disposed of without contamination of surface or ground water and without creation of a nuisance, is sufficient inducement to seek a less costly means of brine disposal or preferably a means for its utilization. With this idea in mind the Oklahoma Geological Survey has investigated certain Oklahoma oil-field brine and processes that might be applicable commercially.

No attempt has been made to find the most concentrated brine or the most valuable brine. Probably the brine from the disposal plant at Moore, southeast of Oklahoma City, can be considered as a "strong" brine. Its dissolved solids per 42-gal bbl. have been calculated from a partial analysis as:

Components	lbs.
Sodium chloride	55.5
Calcium chloride	11.75
Magnesium chloride	2.5
Calcium sulfate	3.5
Calcium carbonate	0.4

What may be called an "average" brine is that from Fitts Pool, south of Ada. Its dissolved solids per 42-gal bbl. have been calculated from a partial analysis as:

Components	lbs.
Sodium chloride	45.0
Calcium chloride	9.25
Magnesium chloride	2.75
Potassium chloride	14.5
Calcium sulfate	1.75
Strontium sulfate	3.0

Using this "average" brine for experimental purposes the first operation was to clarify by adding approximately 1.5 oz. of hydrated lime per barrel of brine for the purpose of bringing the pH to a point where iron and alumina would separate upon aeration. Sedimentation followed by filtration on a rapid sand filter rendered the brine free from iron, alumina, and suspended matter.

The difference between rainfall and evaporation, especially in western Oklahoma, makes it possible to undertake natural evaporation similar to that carried out in California for the production of salt from sea water. Under this procedure, the "average" brine after clarification and concentration to 10% of original volume, yielded a crude salt and bittern with the following compositions:

Salt	%
Sodium chloride	96.16
Calcium chloride ($CaCl_2 \cdot 2H_2O$)	1.76
Magnesium chloride ($MgCl_2 \cdot 6H_2O$)	0.54
Moisture	1.65

Bittern Sp. Gr. 1.300 Solids	%
Sodium chloride	5.93
Potassium chloride	2.92
Calcium chloride	69.55
Magnesium chloride	21.60

A combination process for the utilization of dolomite, a low-value mineral, and the clarified "average" brine has been investigated. On the flow-sheet (Fig. 1) the clarification process can be followed from the well to storage.

In a separate operation dolomite is burned to caustic dolime, the carbon dioxide passing out from the kiln as flue gas. The dolime is thoroughly slaked, whereby a mixture of milk of lime and milk of magnesia is obtained. The brine and a calculated quantity of slaked dolime in the form of a slurry are run into a rotating drum which is air-tight except for release and control valves.

In the meantime the flue gas is scrubbed and the CO_2 absorbed and regenerated in concentrated form by well known methods. The CO_2 is then passed into the rotating drum containing the brine and slaked dolime until tests indicate the proper amount of CO_2 has been taken up, with the conversion of the calcium from both the brine and the dolime into insoluble calcium carbonate (precipitated chalk) and the replacement of the calcium chloride in the brine by magnesium chloride.

The calcium carbonate is removed, washed, dried, and could be sold as such or burned to a high-purity quicklime. The residual brine contains salt, potassium chloride and a much higher concentration of magnesium, depending upon the amount of replaceable calcium chloride in the original brine.

The residual brine may be evaporated and salt crystallized, leaving a bittern heavy in magnesium chloride, or the magnesium may be precipitated as basic magnesium carbonate by use of soda ash. The relatively high-purity sodium chloride solution is adaptable to electrolysis and the production of caustic soda and chlorine.

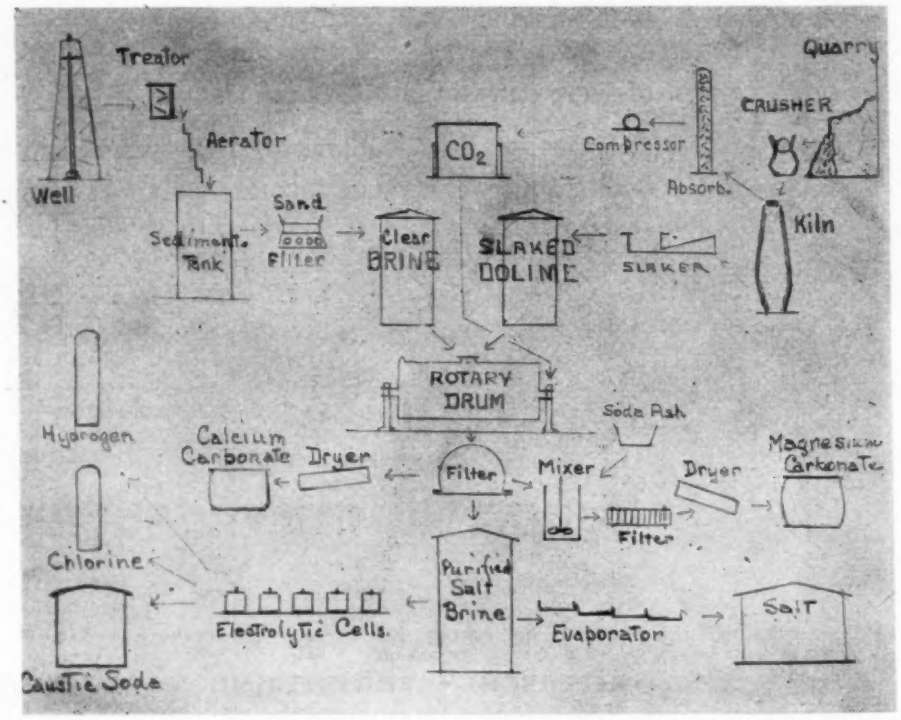
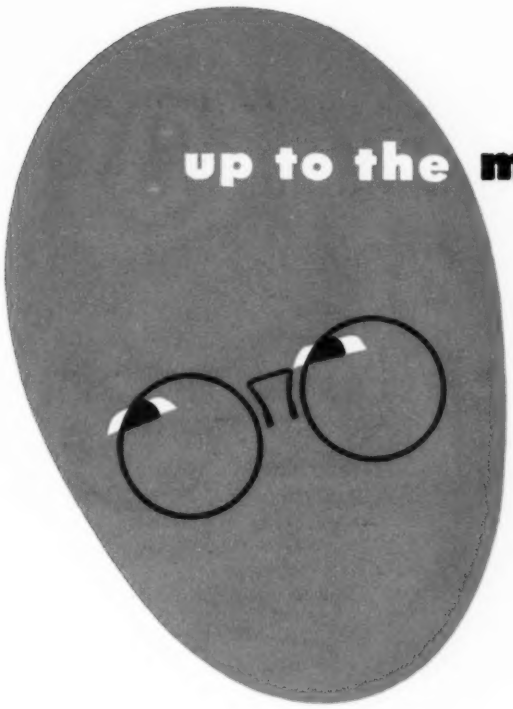


Fig. 1—Flow sheet for conversion of oil field brine and dolomite to calcium and magnesium carbonates



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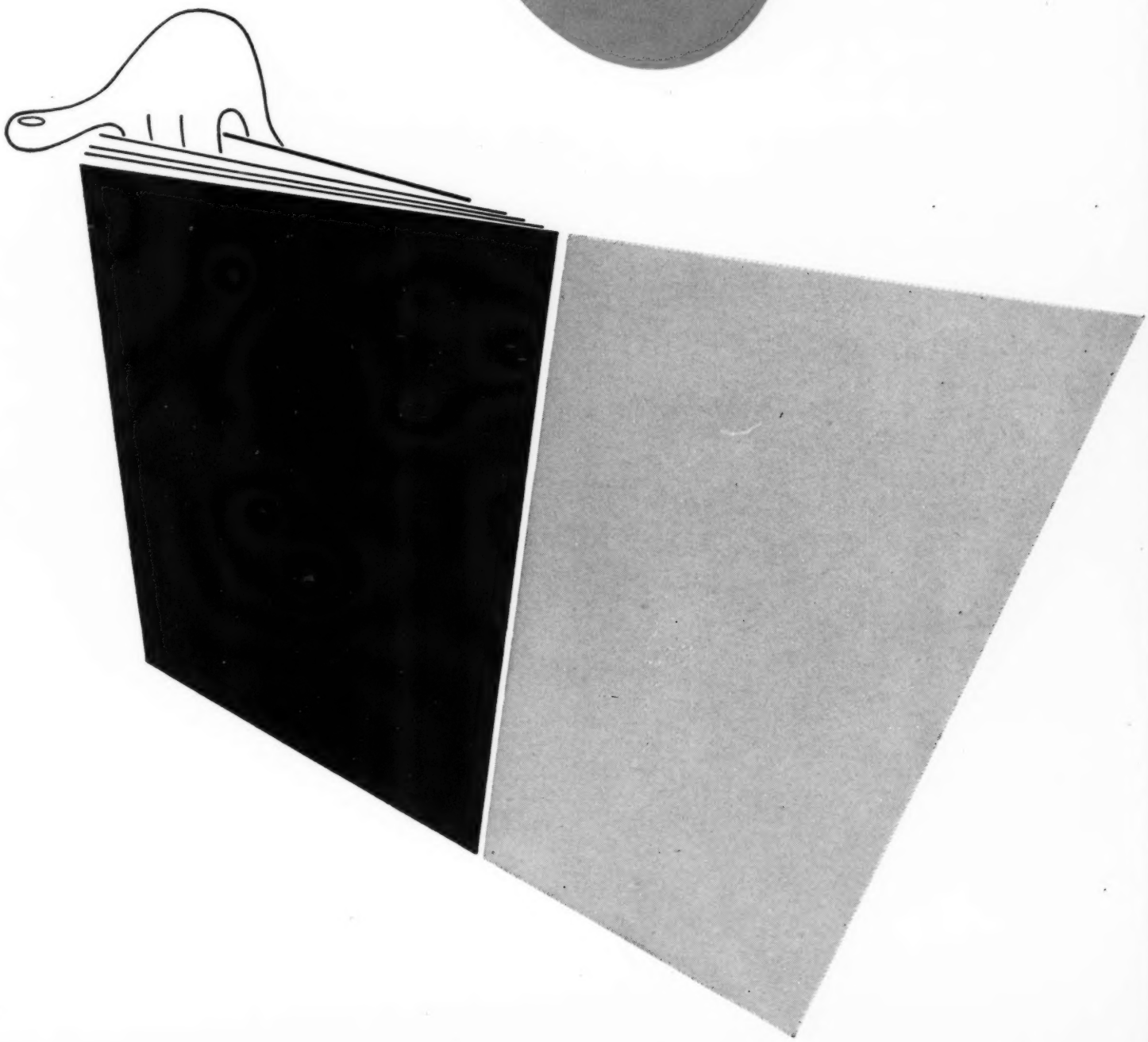


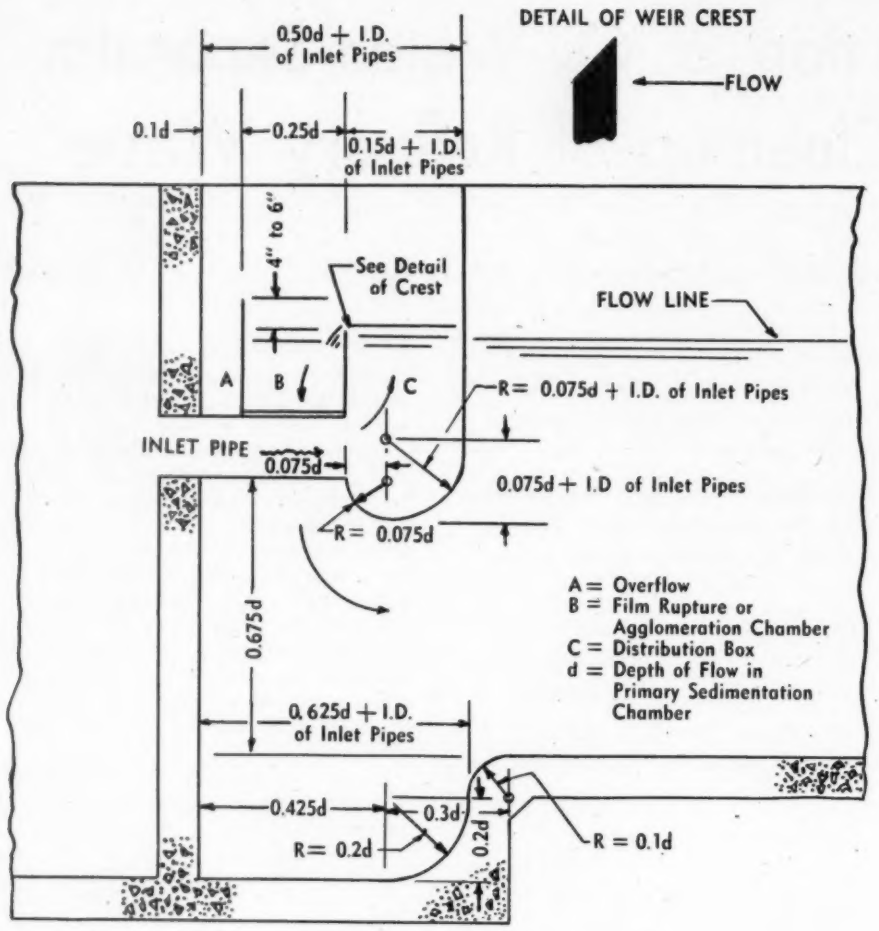


Fig. 1—Design of inlet end of secondary section

greatest velocity may be from 30 to 50% higher than that calculated as the average velocity. Consequently, the length of the secondary basin arbitrarily is made 40% greater than that of the primary basin. In establishing this greater length, consideration has been given the influence of the secondary oil retention baffle which is designed to give, it is believed, the greatest possible effectiveness. This will be taken up later. For purposes of clarification, using the example being carried through this entire discussion, the length of the secondary sedimentation basin will be:

13 ft. + (13 × .4) = 18.2 ft., or
18 ft.-2½ in.

from the downstream face of the distribution box to the most extended upstream point of the oil retention baffle. The depth will be 7 ft.-9 in. and the width 19 ft-6 in.

The flow-line of the secondary section will be controlled as to elevation by the outfall weir. This weir is constructed in general in the same way as the outfall weir of the primary section, except that its height above the separator floor is reduced. The height is controlled by the flow-line and is equal to the flow-line minus the head on the weir crest. This, of course, will be the same depth of head as on the crest of the primary section outfall weir. Again referring to the example:

Height of primary section flow-line:—7.8 ft. × 0.94 = 7.332 ft. = height of secondary section flow-line.

7.332 − 0.145 = 7.187 ft. = 7 ft.-2¼ in. = height of the secondary outfall weir.

Oil Retention Baffle

The oil retention baffle of the secondary section has been designed to provide for retention of the greatest amount of oil possible. The design, because of the unique baffle which results, requires some explanation.

It should be understood, and remembered at all times, that in separator design the various forces which must be related and controlled all are small in absolute values. Relatively, however, these forces can be great in their effect. It becomes necessary therefore, to evaluate the forces and the effects they have one on the other. Then it is possible to turn these effects to useful purposes. This is particularly true in the design of the oil retention baffle for the second stage of the separator.

When a filament of water, moving along the longitudinal axis of the sedimentation basin in a horizontal plane, contacts a vertical interrupting surface (i.e., is normal to the surface) such as an oil retention baffle, its energy is dissipated in a pattern on the vertical surface 360° in its directional effect. The energy is dissipated in eddy currents. The upper half of the symmetrical pat-

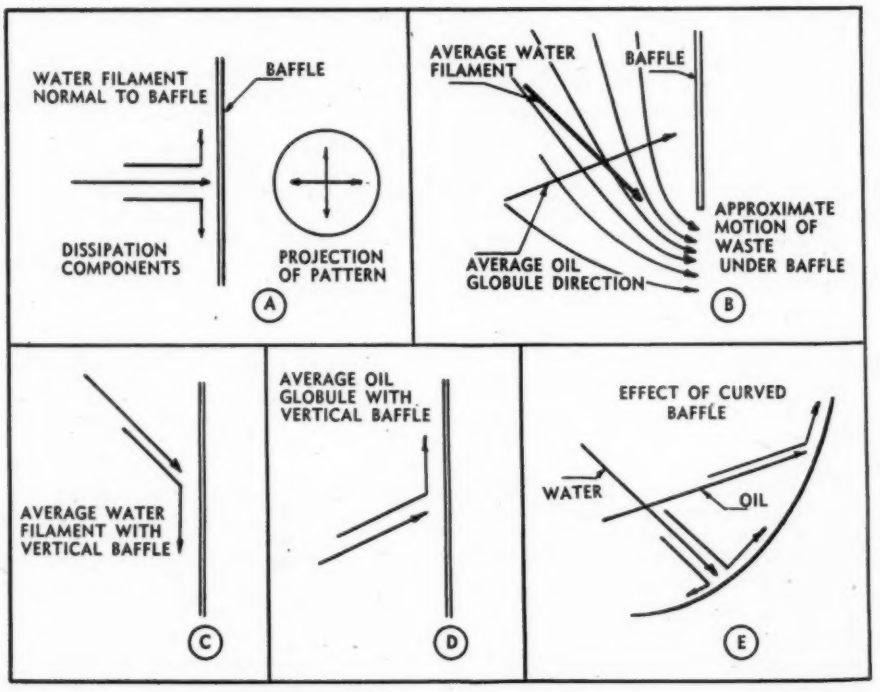
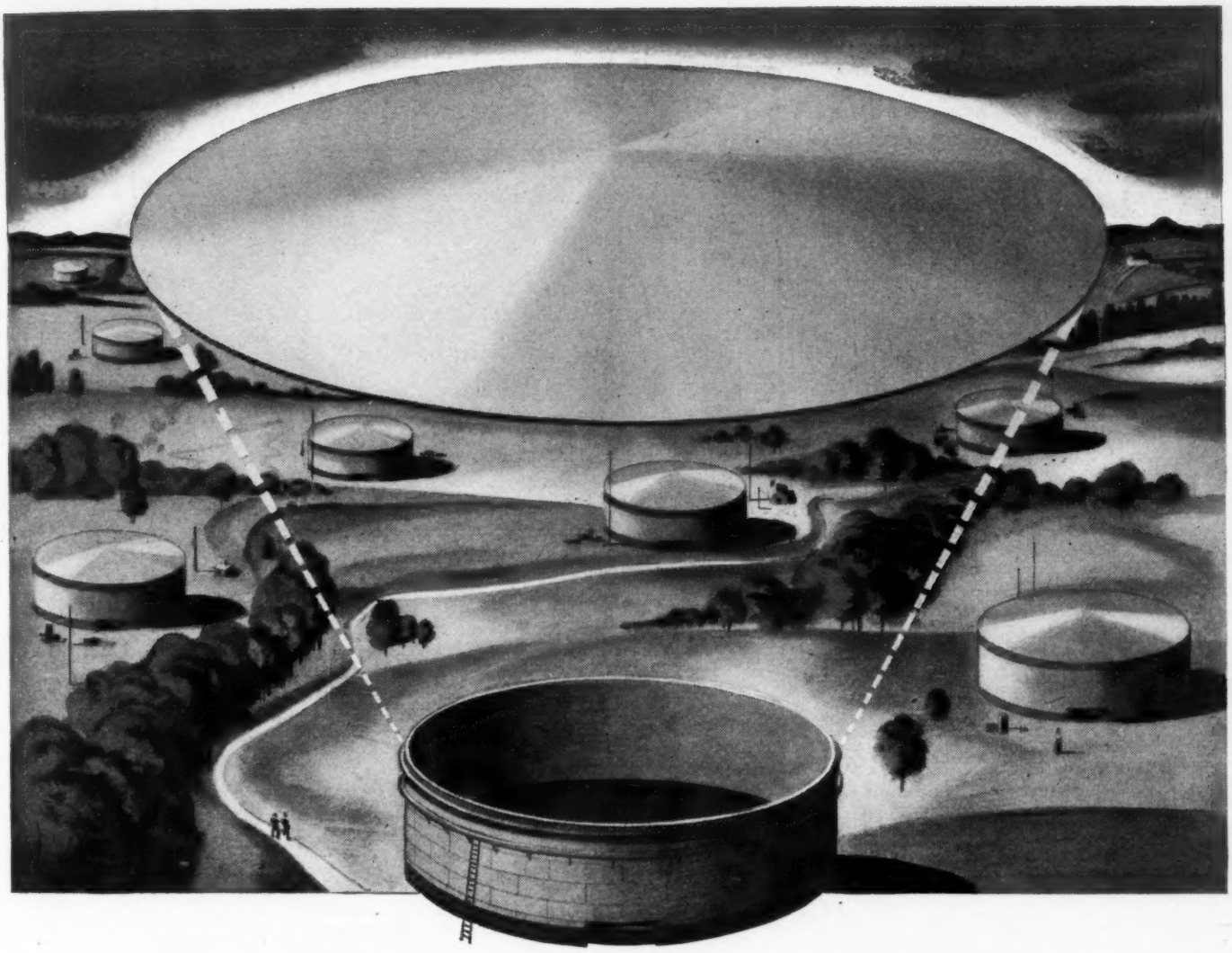


Fig. 2—Action of water and oil flow as affected by oil retention baffle in secondary section



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tern moves upward, and tends to sweep any minute globules of oil up toward the flow line. This will interfere not at all with the effectiveness of the separator. But the lower 180° of the pattern will move downward, and will tend to carry any oil globules downward and into the current moving under the baffle and out of the separator.

The conditions mentioned all are theoretical, and assume the forward velocity of the flow (i.e., the filament) to be normal to the baffle. Actually this is not the case. The body of water all must pass under the baffle and the course of the filament, both theoretical and approximately actual, are shown in Fig. 2. The effect of this downward motion of the water is obvious, and this effect, if it takes place near the bottom of the baffle, will act to reduce the degree to which the separator will retain oil in very small globules (i.e., separator effectiveness).

To overcome this condition, the oil retention baffle is curved so that the water filament path will not be normal to any point in the baffle. The form this curvature takes is the quadrant of an ellipse. The design of the curvature is based upon the assumption that the downward movement of the water as it approaches the baffle is at an angle of about 45° with the horizontal, and that the oil globule is moving in its normal vector path. The evaluation of these forces is based upon the kinematic energy of the oil and the water i.e., mv^2_2.

Using the symbol R_o for the rate at which the oil globule is moving:

$$R_o=\sqrt{V^2+V^2}$$

and R_w for the rate at which the water is moving:

$$R_w=\sqrt{V^2+V^2}$$

the kinematic energy of the oil then is:

$$O_k=\frac{m\times(\sqrt{V^2+V^2})^2}{2}$$

and that of the water:

$$W_k=\frac{m\times(\sqrt{V^2+V^2})^2}{}$$

The most adverse effect of the kinematic energy of the water is when the water filament is normal to the point of impact. Then the total energy can be divided by 2. This value is used, therefore, in establishing the curvature.

The curvature is determined by solving the equation for the ellipse:

$$\frac{x^2}{a^2}+\frac{y^2}{b^2}=1$$

In this equation $a = O_k$ and $b = W_k/2$. For convenience, the final values, which for length are in terms of feet, are converted to inches by multiplying by 12.

Using the example being followed, $O_k = 1.23 \times 12 = 14.76$ ins. and $W_k/2 = 1.03 \times 12 = 12.36$ ins., i.e., $a = 14.76$ and $b = 12.36$. Solving the above ellipse equation:

$$x=a\sqrt{1-\frac{y^2}{b^2}}$$

The solution of the equation, using as the $Y-Y$ axis the flow line of the secondary section, and as the $X-X$ axis the extent of depth into the flow, is presented as a tabulation in Fig. 3, which also shows the developed curvature. Above the flow line the baffle is vertical, but on the submerged end of the baffle, regardless of the extent of the curvature, a return curve is developed to minimize the eddying effect which would result from the change in direction of flow were the edge of the baffle not so protected.

The radius of this return curve, which takes the form of a half circle, is designed in relation to the depth of the sedimentation basin below the edge of the baffle. The radius should be 5% of the depth below the edge of the baffle. Actually, the nearest standard size pipe, cut in half lengthwise and welded to the baffle edge, will be satisfactory. This cannot be done in a haphazard manner, however, and expected to be effective. All surfaces must be smooth and free of welding ridges or other interfering irregularities. The baffle should be adjustable so that at all times the bottom will be truly level, and if not, can be made level. This is of extreme importance to distribution and separator effectiveness. It is essential that this baffle be made of metal.

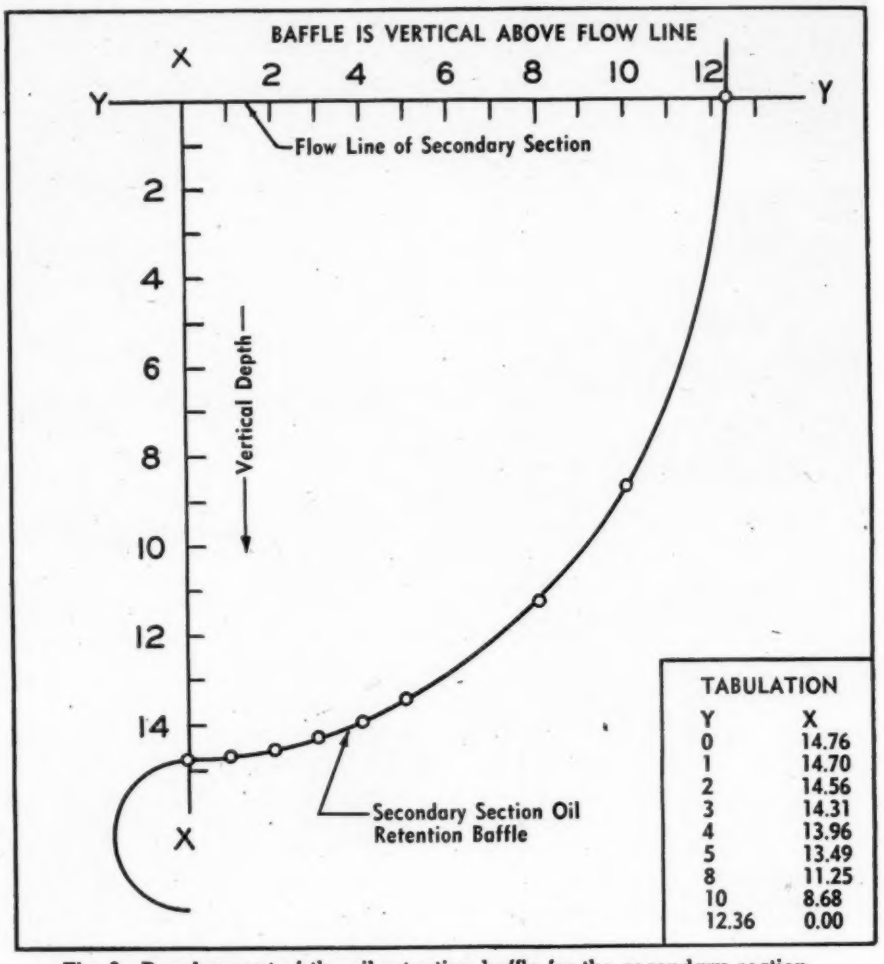

Fig. 3—Development of the oil retention baffle for the secondary section

Question of Cleaning Equipment

The question of whether or not to install cleaning equipment in the second stage of a separator often has been raised. The answer will depend entirely upon the waste being treated. If the waste, in terms of actuality and not "wishful thinking," is in good condition for separation, the probabilities are that there will be no need for frequent cleaning. At intervals determined by the rate of accumulation of bottoms settlings these can be removed by dredge pumping. If the intervals between cleaning operations, under conditions of good operation (i.e., when bottoms accumulation is not simply neglected), are short, then the cleaning equipment will provide operating economy.

As a result of the uncertainty which attends this matter, a procedure has developed which presents what is probably the best answer. Of the entire cleaning facilities, the sludge reservoir and sludge pumping header, valved branches and pumping connections are installed (Fig. 4). Also, the bearings and guides of the flight scraper are installed, but the

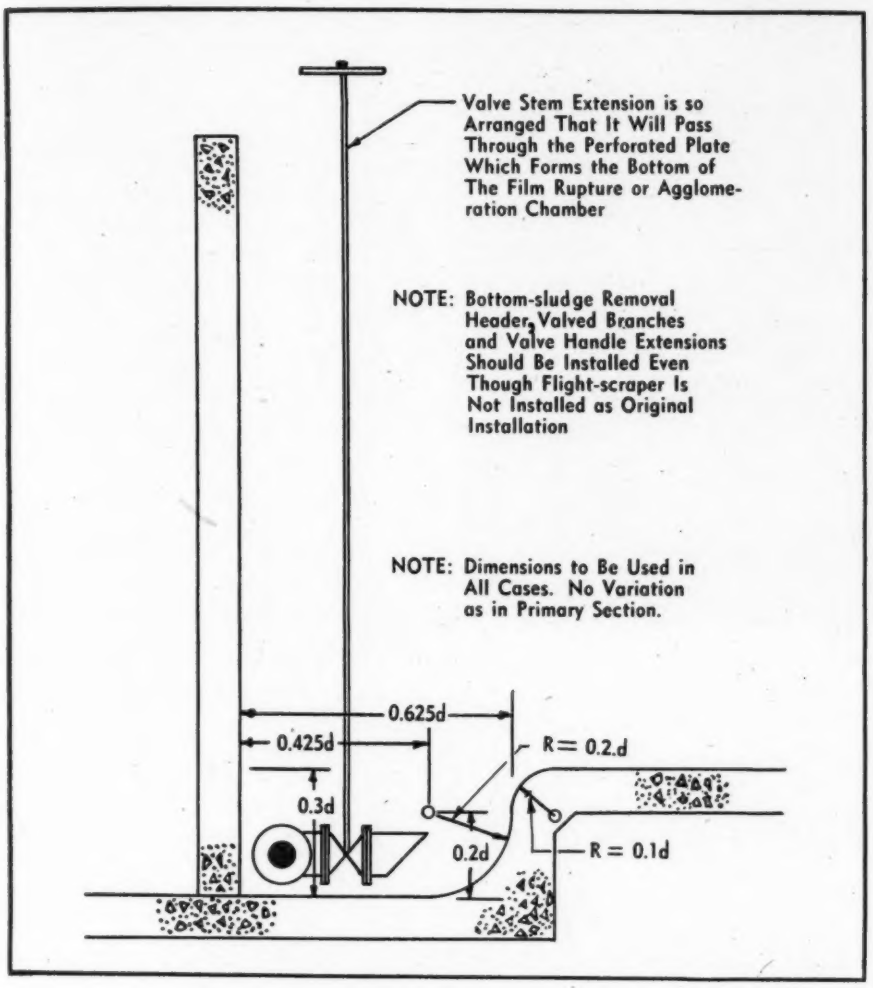
Valve Stem Extension is so Arranged That It Will Pass Through the Perforated Plate Which Forms the Bottom of The Film Rupture or Agglomeration Chamber
NOTE: Bottom-sludge Removal Header, Valved Branches and Valve Handle Extensions Should Be Installed Even Though Flight-scraper Is Not Installed as Original Installation
NOTE: Dimensions to Be Used in All Cases. No Variation as in Primary Section.
0.625d
0.425d
R= 0.2d
0.3d
0.2d
R = 0.1d

Fig. 4—Cleaning arrangement for secondary section

flight scraper itself is omitted to be installed later, if necessary. Even this much of the installation should be under the supervision of the vendor.

The main features of a gravity type, oil-water separator in its entirety are shown in Fig. 5, and the design of all these items has been presented.

Summary

It should be understood that the top of the separator end and side walls will vary in distance above the flow-line, depending upon the distance of the plant sewer system below grade. The "depth" as used in the design discussion is the depth of flow and not the overall depth of the separator. Structural design has not been considered in the discussions.

After the waste water passes over the out-fall weir of the secondary section, it is beyond the zone of further treatment. Consequently, the connection from the outlet chamber can be made at any convenient point. If desired, a single outlet chamber extending along the ends of a series of parallel separators may be used, but will present a problem if it becomes necessary to close off a given section. The elevation of the connection from the outlet chamber to the disposal sewer or ditch, or to any subsequent treatment equipment never should be so great that it causes interference with free fall over the outfall weir. This can happen if the water level in the outlet chamber becomes too high.

Examination of the design fundamentals will reveal the emphasis placed upon separator width, especially when there are a number of units in parallel, as compared to length. Separators, when at all practicable as treatment equipment, need not be excessively long. This contributes to ease of operation and maintenance.

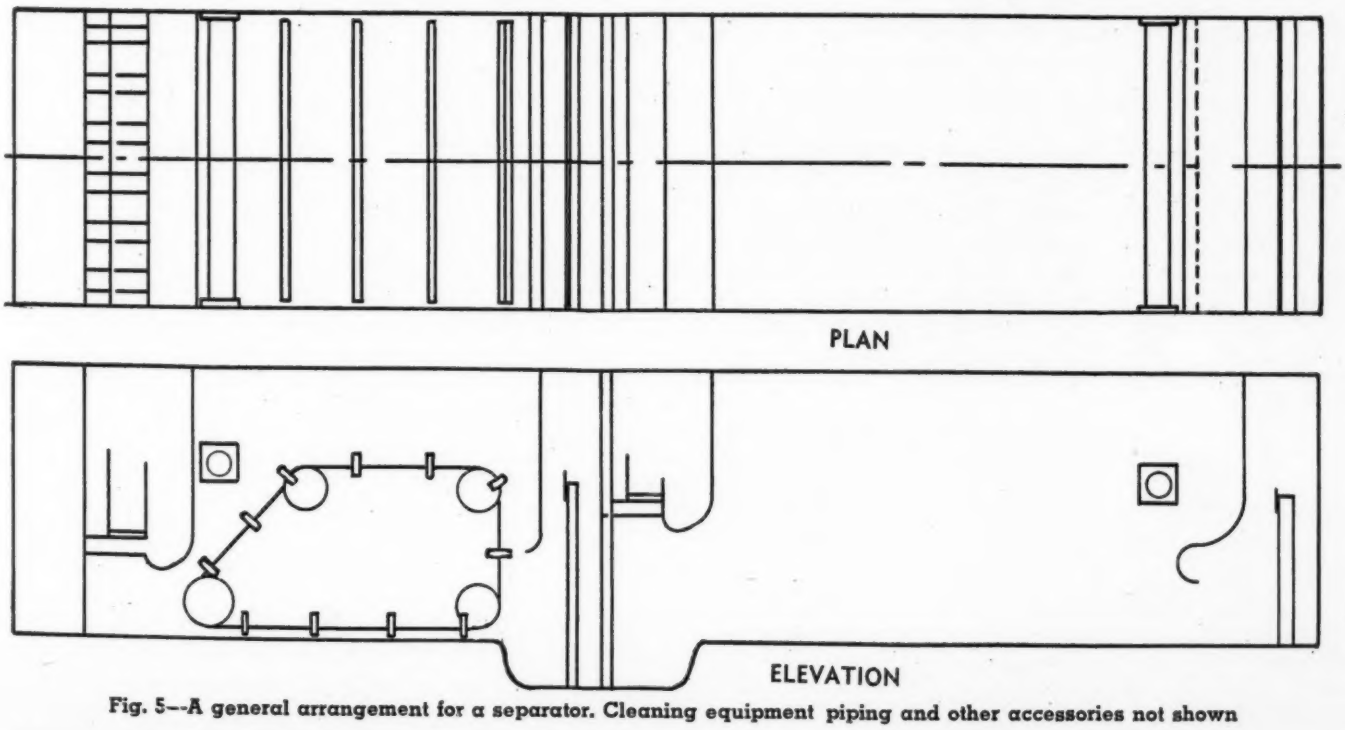

Fig. 5—A general arrangement for a separator. Cleaning equipment piping and other accessories not shown

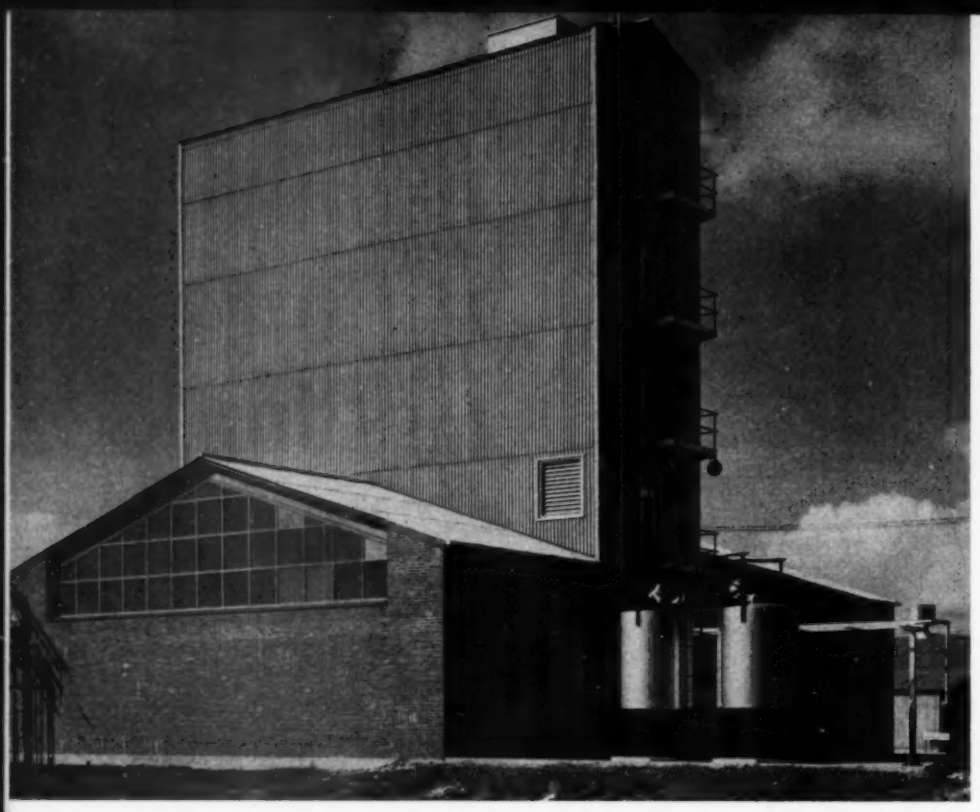

Fig. 1—This 68-ft. high building houses Humble's 6 b/d pilot Fluid catalyst cracking unit at Baytown, plus a small laboratory and office. Behind the building is the nitrogen generation plant. Tanks shown hold feedstock

CATALYTIC CRACKING

"Kitten" Cracker Works Out Diet For Commercial Fluid Units

Savings are secured and catalytic cracking operations expedited, at Humble's Baytown refinery, by first trying out new ideas for the commercial Fluid units in a midget plant designed to duplicate operations of the big "cats" as far as practicable. The "kitten" plant can charge a wide variety of stocks and catalysts; volumes required are small and cost far less than for experimenting on the commercial units. Data from pilot plant operations are taken as "indicative" of results from the commercial units.

THE installation of catalytic cracking facilities at U. S. refineries during the past few years has brought up many problems in operating conditions for these types of units, processing techniques, and development of new charge stocks. Questions of how to improve yields; better product quality, develop new products and utilize low-value refinery by-products to produce more saleable materials by means of catalytic cracking have demanded attention. Changes in equipment design also have been involved.

It is not usually desirable to carry on experimental work on the full-scale units themselves because of the cost involved and the possible interruption to commercial operations. The answers to some of these problems, at least as far as Fluid catalytic cracking units are concerned, are being secured through operations of small pilot plants, popularly called "kitten" crackers. The refiner interprets data from the pilot plants in terms of his large scale commercial units.

It is a matter of the "kitten" deciding the care and feeding of the big "cats" (with apologies for the pun.) The unusual feature in the matter is that the pilot plants, of which there are about a dozen in existence, were built in most cases long after the commercial units had been in operation.

A recently commissioned pilot Fluid unit is that of Humble Oil and Refining Co., at Baytown. Mechanical design and construction was carried out by C. F. Braun & Co., Alhambra, Calif. The contractor's bill nearly equaled the cost of a small commercial topping unit in prewar days, although of course the cost was far less than for either of the two 30,000 b/d commercial scale Fluid units erected at Baytown some years before.

The "kitten" is designed to duplicate the operation of the large units at the refinery on a greatly reduced scale, as far as practicable. It is housed in a five-story building 68 ft. high. See Fig. 1. Rated capacity is 5 to 7 b/d. The reactor zone consists of 25 ft. of 4-in. pipe, the regenerator zone 24 ft. of 6-in. pipe. The catalyst transfer lines are 1 in. in diameter, and the catalyst standpipes 1½ in. The two vertical-type slide valves cost about $200 each, only a very small fraction of the cost of one for a full-grown "cat."

Abbreviated on Humble's records as PFCCU, the "kitten" cracker is built throughout of 18-8 stainless steel. This material of construction was used to preclude possibility of rust or scale plugging small lines or motor-operated valves. The additional cost of the stainless steel over carbon or low alloy steel is justified by the increased on-stream time for the unit.

The pilot plant is fully equipped with instruments for control purposes. In fact, it has more instruments than a full-scale unit. There are three control panels for the plant instrumentation, for

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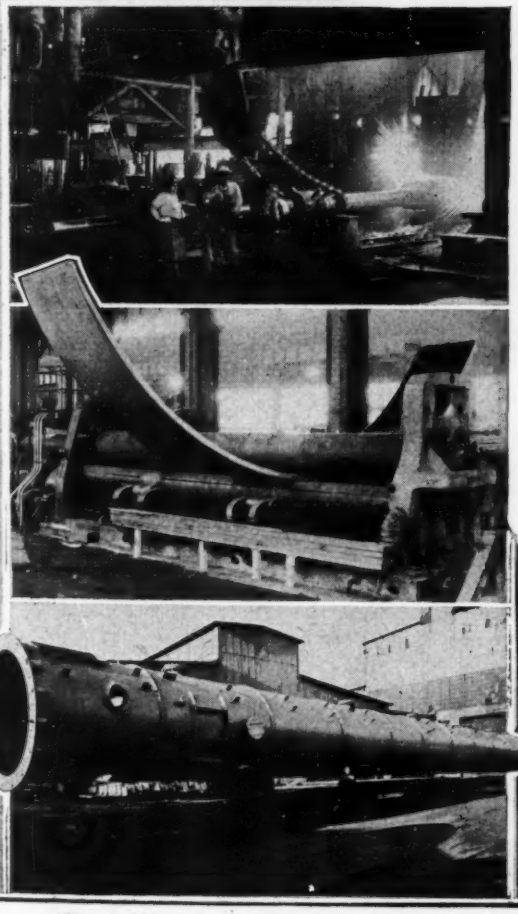

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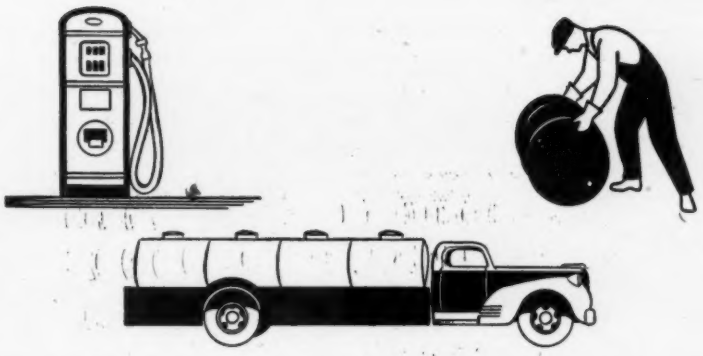

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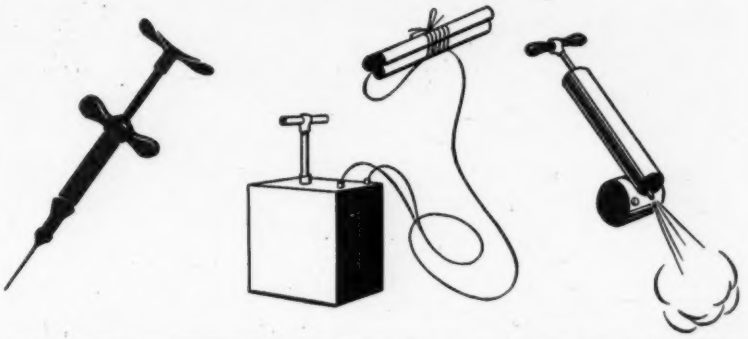

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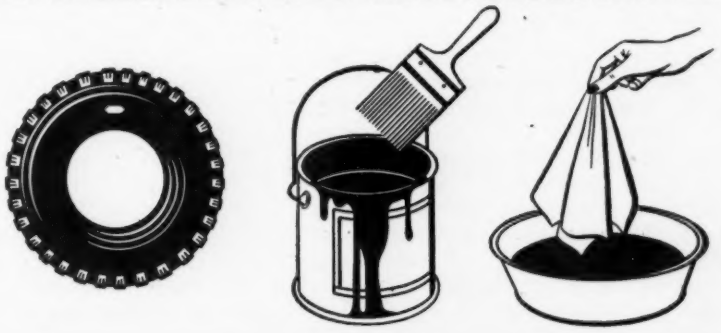

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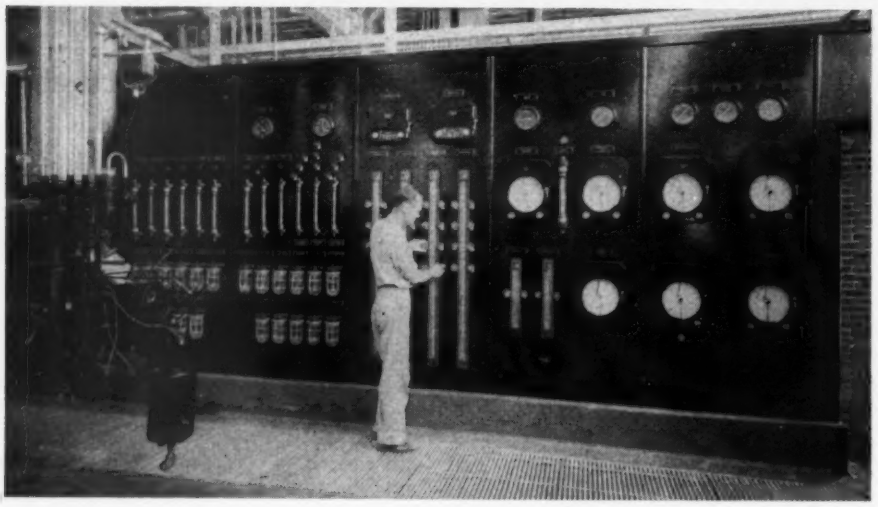

Fig. 2—Instrument panel for process flow and pressure of "Kitten" cracker. Differential flow instruments are located at the left, differential pressure controllers at the right

process flow and pressure, heat and temperature, and gas metering, respectively. Fig. 2 shows the instrument panel for process flow and pressure.

Relay systems are not needed with the instrumentation, since pipe sizes and distances from point of control or measurement are not great. Also, there is no necessity for the elaborate alarm signals required on the full-scale unit because quantities of material handled are very small with consequently reduced danger to structure or operating personnel if an upset occurs. Nevertheless, every reasonable safety precaution has been taken at every potential danger point in the pilot plant.

Charge may be any refinery stock, or blend of previously cracked and virgin materials. The unit is equipped to charge stocks of widely different characteristics, including kerosine treating extract, petrolatums, solvent lube extract, heavy naphthas and gas oils. Any "Fluid" type catalyst can be used, although usually "equilibrium catalyst" from one of the large units is used. This is representative of the average condition of catalyst found in field units during a run. About 200 *pounds* of catalyst is required for the little plant against 500 *tons* in the full-scale plant. This is a double advantage in that catalyst cost is small, less than $100 for an experimental run and operations with small batches of experimental catalysts can be carried out.

'Cat' and 'Kitten' Compared

Basic operation of the pilot plant duplicates the commercial units in many ways, yet differs sharply in others. Generally pure nitrogen is used to strip oil from catalyst; steam is used commercially. Nitrogen also is used for instrument bleeds instead of air, steam, or natural gas. The nitrogen is prepared in another midget plant. Three operators per shift run the pilot plant, compared with six to seven for the big units. There is no provision in the experimental unit for waste heat utilization in generating process steam, since only small quantities of heat could be recovered. Liquid products are charged to the refinery slop system for recovery after inspection work is completed.

Primarily, in the pilot unit design it is desired to simulate commercial operations, rather than to scale geometric proportions accurately. For instance, ratio of reactor diameter to length is less than 2 to 1 in the field unit; in the pilot plant this ratio is about 1 to 75. Since volumes involved are small, leaks cannot be tolerated and most pipe connections are seal-welded to eliminate this possibility.

A much greater surface area of lines and vessels is exposed to the atmosphere per unit of volume than on the full-scale units and the heat losses are, therefore, proportionately greater. Hence nearly every vessel or line carries a minimum of 4 in. of insulation and in addition is externally heated throughout by electrically heated resistance wire to maintain thermal losses at a minimum. One of the three control panels carries the temperature indicators, recorder-controllers and manual current controls for electric heating.

Volumes of gases are small and, when steam is used in stripping or for injection, it is ultimately condensed and weighed. Care must be used at instrument bleeds not to dilute the reactor and regenerator vapors beyond that existing comparably in a full-scale unit. Carbon deposition rate is measured by flue-gas analysis and frequent determinations are made of carbon on the spent and regenerated catalyst.

One of the most unusual features of the pilot plant distinguishing it from the field units is the use of ceramic filters (long tubes of "Aloxite") to eliminate catalyst loss from the vessels in place of cyclone separators and Cottrelle precipitators. Care is required to avoid thermal stresses with resulting failure of the ceramic filters and "fritted" 18-8 stainless

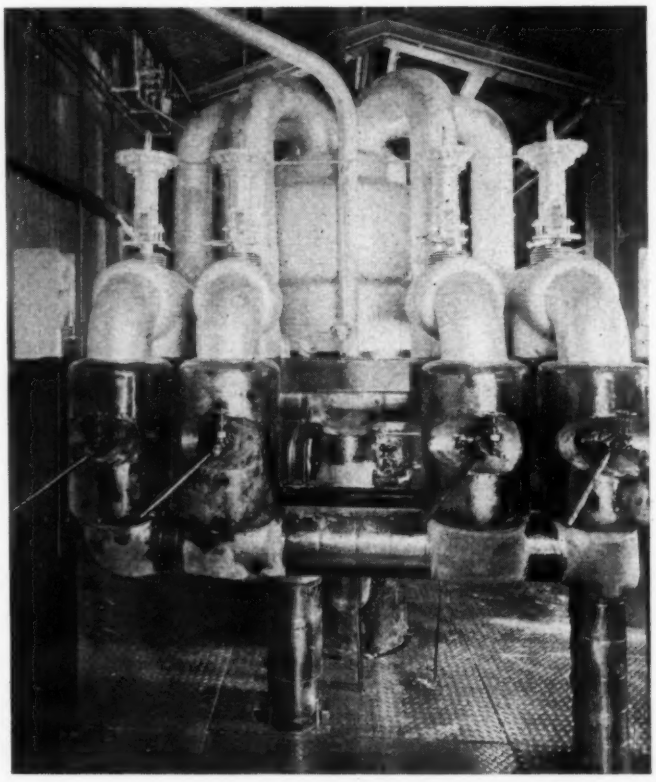

Fig. 3 — View of filter section of regenerator of Fluid pilot plant showing regenerator outlet lines (top) and motor valves for blow-back control

steel filters are under consideration for future installation.

Four of these filters are installed on the reactor and regenerator vessels, three of which are on-stream while the fourth is being blown back, with steam at the regenerator and recycle dry process gas (C_3 and lighter) at the reactor. The cycle is controlled by timers operating 3-way valves on a 5-minute cycle. Each filter is blown back every 20 minutes. Fig. 3 shows the filter section of the regenerator.

All equipment, including the fractionators, is suspended at the mid-point to minimize expansion difficulties caused by temperature changes. In addition, regenerator and reactor overhead piping is suspended at the pipe manifold shown in Fig. 3 by counterweights to reduce the load on the relatively small vessels.

Pilot Plant Operation

Charge to the "kitten" cracker is stored in two 30-lb. tanks and from these pumped to one of two weigh tanks, both of which also are volumetrically calibrated and sized for a 2-hour run at normal charge rate. Tanks are heated with steam to 200°F. for easy pumping with viscous stocks and to minimize any calibration and pumping rate errors. Two smaller secondary charge tanks and pumps also are available if it is necessary to charge two oil streams to the unit. These are volumetrically calibrated.

All weigh tank connections are flexible metal hose. The oil charge is pumped to the unit with reciprocating pumps taking suction on the tank; the pressure is raised to that desired and the charge passes through preheater coils immersed in molten lead baths (electrically heated) to the vertical slide-valve, where it mixes with catalyst in the body of the valve. A view of equipment arrangements are shown in Figs. 4-5. The piping arrangement is such that injection of steam or inert gas can be added to the preheated charge as desired and at any temperature. The charge is usually preheated to approximately 700° F. and is therefore only partially vaporized.

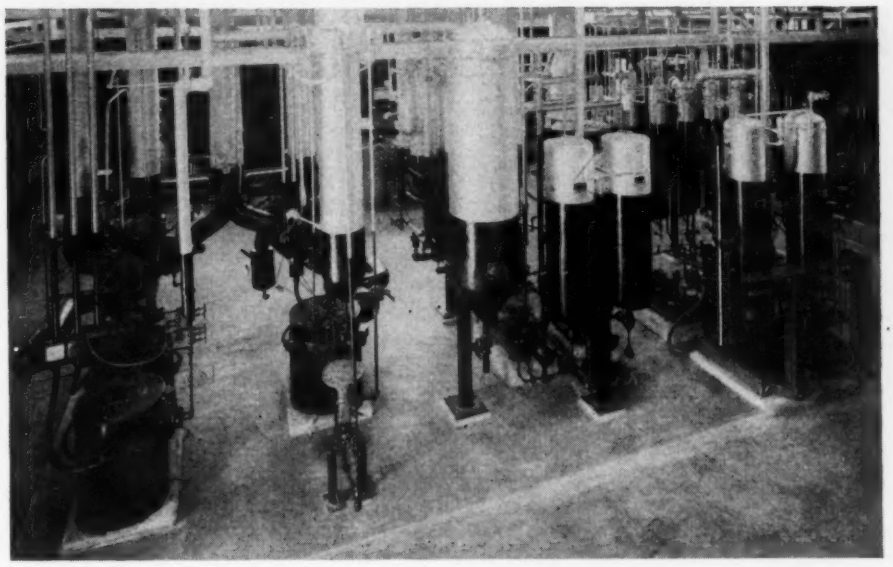

Fig. 4—Main floor view of "Kitten" cracker. Vessels, left to right, are: lead bath charge preheaters, regeneration air preheaters; and catalyst addition hopper, catalyst drop-out hopper, two secondary charge tanks and pumps, and two primary charge weight tanks. In background are the three control panels for the pilot plant

Total reactor product is cooled to approximately 100° F., then passes to a low-pressure accumulator where uncondensable gases are separated from the condensed liquid. Gas is compressed to 250 psi. and flows to the high-pressure accumulator where liquid from the low-pressure accumulator also is pumped. Gas from the high-pressure accumulator is split into two streams. One is used as recycle gas, for regenerator filter blowback and for maintaining a constant pressure on the low-pressure accumulator. The other stream is vented to the gas product system where it is carefully metered and sampled for later analysis. It is then discarded to atmosphere.

The liquid stream from the accumulator also is split, part being used to quench the reaction product immediately after it passes the reactor pressure control valve to prevent thermal cracking and the balance is charged to the debutanizer.

Usual operation of the pilot plant includes making only one liquid product. Accumulator liquid is fed directly to the debutanizer, which consists of 30 ft. of 6-in. pipe packed with beryl saddles (ceramic). This column is designed to take all C_4 fraction overhead with a minimum of C_5's. The overhead product flows to the gas product system and the debutanized liquid is weighed and accumulated in motor oil drums.

If it is desired to break down the product still further, the hot reactor effluent stream is charged directly to the fractionator. This is a 20-ft. section of 8-in. pipe packed with Berl saddles and equipped for one side draw-off. Bottoms, usually a heavy gas oil plus heavy cycle gas oil, flow immediately to storage. The side stream is sent to storage also or, if desired, can be recycled to the reactor inlet. The fractionator overhead flows to the cooler, low pressure accumulator and thence to the debutanizer. In every case these streams are weighed and sampled before storing. Fig. 6 is a photograph of the fractionator and debutanizer with associated equipment.

Laboratory facilities at the pilot unit are restricted to control tests needed quickly for operation of the unit. In

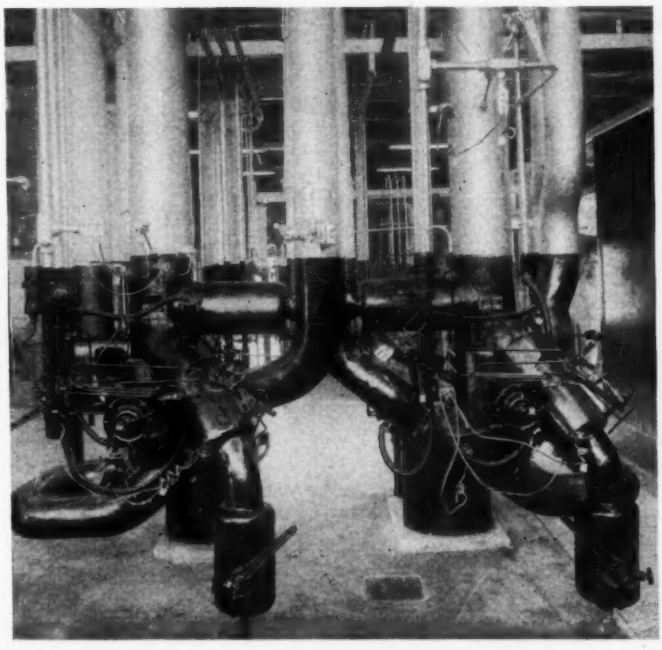

Fig. 5—Reactor and regenerator stand pipes, risers and slide-valves. Although they appear large, standpipe is 1½-in. line and risers are 1-in.; they carry about 4-in. insulation. Catalyst sample nozzle on reactor is in left foreground

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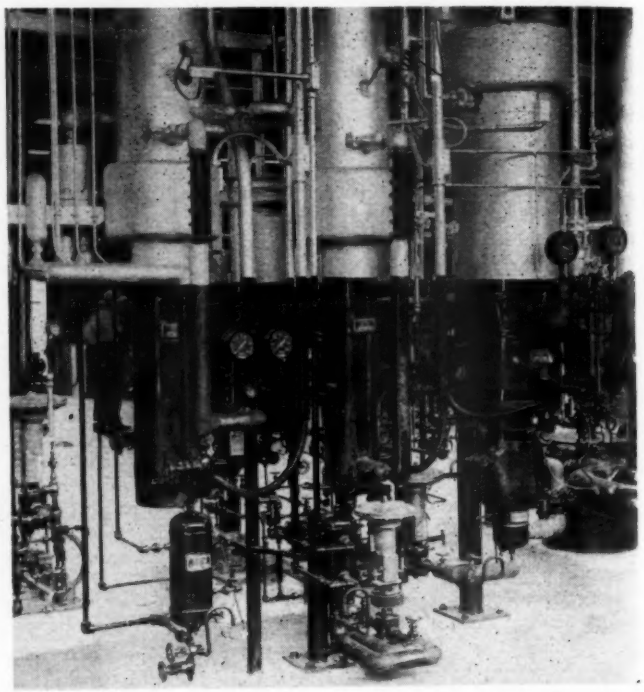

Fig. 6—Ground floor view of fractionation facilities. Left to right, columns are cycle stock fractionator, debutanizer and tar separator

general these consist of analysis of the flue gas, nitrogen purge stream and determinations of the carbon content of catalyst. All other samples are analyzed in the refinery control laboratories. Run calculations are made by chemical engineers stationed at the unit.

An ingenious system has been developed for taking gas samples. On the third floor of the unit a barrel is kept filled with saturated solution of magnesium sulfate, a line connecting it to the sampling area on the ground floor. The sample bomb is connected to the line with a hose, purged and filled with solution. The gas sample is taken by displacing the salt solution back to the barrel.

A description of the pilot plant would not be complete without discussing facilities for nitrogen production. A Kemp inert gas generator is used, which burns a carefully controlled mixture of natural gas and air to cabon dioxide and water with a minimum of carbon monoxide and free oxygen. The Kemp gas is treated in a Girbotol plant (methyl ethanolamine) to remove carbon dioxide and the treated gas is therefore essentially pure nitrogen. This system is capable of producing 1000 standard cu. ft. of nitrogen per hour, 99+% pure, delivered at 120 psi gauge.

Interpretation of Data

When problems in connection with catalytic cracking are being considered for study in the pilot plant the first consideration is that they have substantial potential value when translated into commercial operations. This is because the "kitten" Fluid unit, like any pedigreed animal, is expensive to own and operate and considerable sums can be expended in its investigations. The results, whether favorable or unfavorable, must be in line with what the work has cost.

Data from pilot plant runs is used to calculate the economics for commercial operations. If the economics are favorable, the required process or mechanical changes are worked out for the big "cats". Pilot plant data cannot be translated to commercial operations in exact percentages but, backed up by scientific judgment, it offers a good indication of commercial unit performance on the same stocks and under the same operating conditions.

An example of a typical process study which could be carried out on the pilot unit is that of countercurrent operation of the regenerator in which spent catalyst is charged to the top while regeneration air enters at the bottom. Such a system is considerably different than the operation of present plant units wherein both the spent catalyst and regeneration air enter the bottom of the regenerator. Such a problem could be investigated on the pilot unit at relatively small expense, and if the operation appeared to be sufficiently attractive, definite engineering and economic calculations could be made. An investigation of this nature would be out of the question if pilot facilities were not available.

The pilot unit is without doubt a valuable research tool. Instead of radically altering operation of an entire refinery to produce a sufficiently large batch of charge stock for the field unit, the experimental stock could be made in laboratory equipment. If the experiment fails, the cost is at most only a few thousand dollars against hundreds of thousands if tried commercially.

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Four Workmen Can Obtain Breathable Air From Single Home-Made Portable Blower

A HOME-MADE hose cart is used to supply breathable air to men working in confined spaces at the Wood River refinery of Standard Oil Co. (Indiana). Developed by Tool Room Foreman William Bacheldor, the apparatus carries a 50 ft. length of 1-in. hose on each of four reels plus a motor-driven air blower.

As shown in the accompanying photograph, the assembly is self-contained and mounted on a two wheeled cart. It can be moved about by two men and towed to the job by truck.

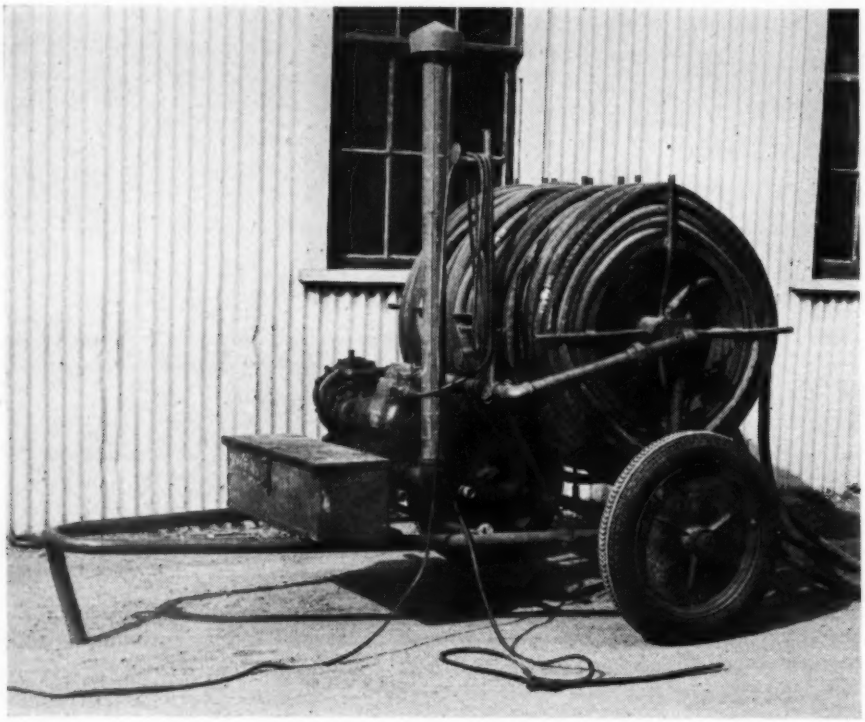
The motor-driven blower assembly is a commercially-available item, intended either for permanent mounting on a truck or to be carried to the job. It also is fitted with a crank to permit operation by hand in the event power or the motor should fail or for use in locations where suitable power is not available.

The vertical pipe is the air-intake, fitted with a removable filter. The box in front carries masks, and a set of small tools for on-the job repairs to the unit. A ground-connection (rod in front of unit) is always made for safety reasons.

The four reels are mounted side by side on a pipe header. A stuffing box is mounted on each side of the reel hubs to prevent air leakage and permit withdrawal of any desired length of hose from an individual reel, independent of the movement of any other. The hose is connected to a nipple in the hub of the reel.

Holes in the pipe header supply air to the four reels. The discharge line from the blower is connected to one side of the header, which serves as an axle for the reels, and is permanently attached to the framework of the cart. The other end of the pipe-header is closed by a screened one-way check-valve.

The check is set to open automatically from the differential pressure created by one man's breathing if the blower is inoperative. Thus it is possible for the workman to get out of dangerous atmosphere without removing his mask or risking suffocation even if something should happen to the blower. It is against safety regulations to leave the cart unattended when men are using the air-masks.



Portable air-line hose-cart and blower pumps air to men working in confined spaces where dangerous atmospheres exist. Men can get enough air to avoid suffocation even if blower is inoperative

Cut Repacking Frequency 66% On Refinery's Acid Sludge Pumps

REPACKING frequency for acid sludge pumps at the Baytown refinery of Humble Oil & Refining Co. has been reduced two thirds by spraying the pump rods with boiler feed water. The washing action of the hot, alkaline water removes sludge accumulations on the rods, packing glands and bolts and neutralizes the residual acid content of this material.

Installation of the sprays was made at negligible cost. A ¾-in. line was run from the boiler feedwater pump discharge header to the sludge pumps, and from this ¼-in. lines were run to each pump rod, the opening coming just above the packing gland. A ¼-in. globe valve is used to adjust the flow over each rod.

The installation on two pumps was an immediate success. It was formerly necessary to repack each pump three times a week; packing for each job cost approximately $10, plus labor. Now only one packing per pump per week is required. It has been noticed also that rod wear has been proportionately reduced although the extent of this saving has not been determined accurately.

Remove Part of Threads to Stop Seizure on HF Plug Valve Stems

Fig. 1—Conventional plug valve stem

Fig. 2—Valve stem with lower portion of threads removed

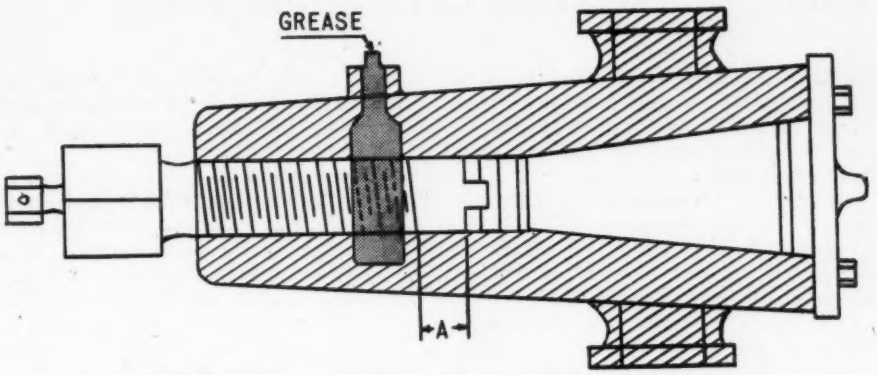


Fig. 3—Improved valve stem in place in plug valve body

HARD movement and seizure in HF alkylation unit, hyper-seal plug valves commonly has been blamed entirely on the plug itself. H. A. Owen, of the Torrance (Calif.) refinery of General Petroleum Corp., discovered that the difficulty was rather in the galling of the valve stem threads.

A conventional stem with threaded end is shown in Fig. 1. When hydrogen fluoride contacts these threads within the valve body, iron fluoride forms, causing galling and taking up the close clearance, thus causing seizure.

The solution as worked out by Mr. Owen was in removing a portion of the threads at the lower end of the stem as in Fig. 2. This permits grease to enter, as shown in Fig. 3, preventing contact of the stem with the troublesome acid. The theads are removed to distance A, which should be within about two threads of the annular packing chamber.

Since adopting this method, General Petroleum's alkylation unit operators have experienced no further difficulties from plug valve seizure.

Mechanical Device Gives Accurate Results In Measuring Clay Thruput from TCC Kiln

By ALFRED KRIEG, Supervisor, Instrument Department, Socony-Vacuum Oil Co., Inc., Paulsboro (N. J.) Refinery

THE operation of a recently developed Thermofor kiln which is used to reactivate percolation clay is continuous, and a measurement of the throughput of the finished clay in terms of tons/hr. is very important to the operation.

Because only rather elaborate and expensive continuous weighing devices have been developed and were available, a simple, inexpensive apparatus was designed. It measures the clay by volume, attaining a highly satisfactory degree of accuracy, making it a practical means of measurement.

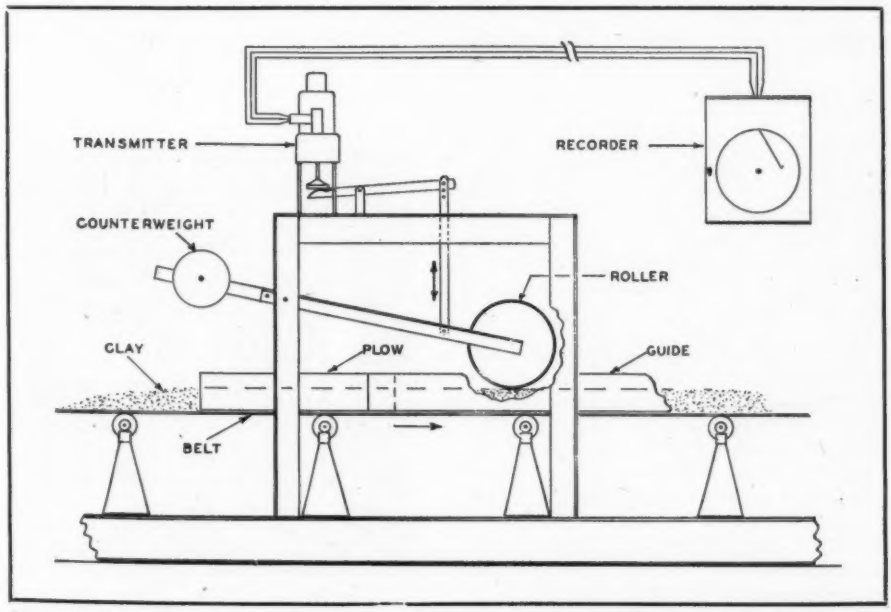


Fig. 4—Apparatus for measuring reactivated clay by volume and converting to terms by weight in tons/hr. Clay moves along continuous belt from kiln to various storage bins

Finished clay is conveyed by belt from the kiln to various storage bins. The measuring device, as shown in Fig. 4, is located along this belt at a convenient location.

The clay passes through a set of vertical plows which serve to uniformly force the material to the center section of the belt giving it definite width. On a shaft extending across the belt, a pivoted leveling vane contacts the clay and forms it into a flat-topped, rectangular shape, with the height being directly proportional to the quantity passing the point.

This height is then measured by a counterweighted roller which transmits the value through suitable linkage to position an armature inside the inductance coil transmitter. The position of the armature in the inductance coil is transmitted electrically to a recorder on the control panel. A uniform chart is used with a calibrated chart factor to give a direct reading in tons/hr.

The speed of the belt, the area of the rectangular section, and the weight per unit volume of clay are computed in order to determine the proper chart factor.

This device has been in continuous service with a minimum amount of maintenance. It is adaptable as an indicating mechanism if so desired by simply replacing the armature and inductance coil arrangement with a pointer and a calibrated scale.

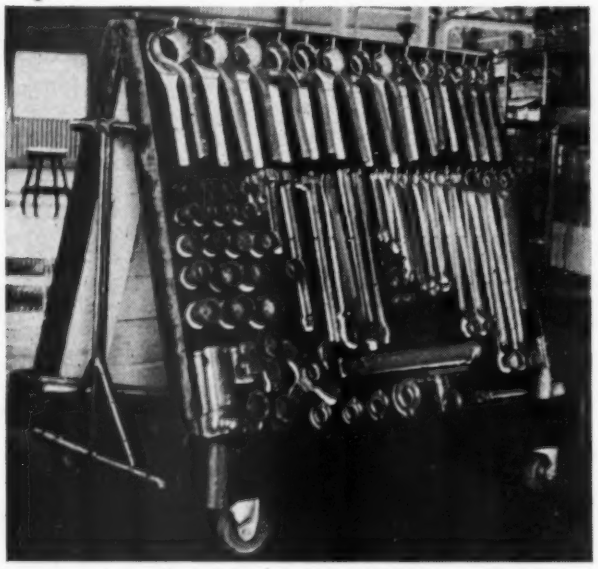
Carry More Tools to Job on Handy Carrier Built on Discarded Oil Purifier Dolly

THE large number of tools needed on various maintenance and repair jobs around a plant are often more than a man or even a crew of men can carry in a small box.

Mechanical department men at the Trinity Gas Corp. plant at Hebbronville, Texas, built a portable tool carrier of large capacity to solve this problem, as shown in the photograph.

The movable base is a discarded dolly originally purchased for an oil purifier, which was subsequently installed in a permanent location. Measuring 38 x 50 in., the dolly rolls on ball-bearing, rubber-tired casters which will not scratch the floor and which provide easy mobility.

Two wooden boards about four ft. square, mounted in an A-type cross-section, complete the unit. They are painted black with aluminum outlines for the various tools and accessories. Space is furnished for about 35 tools of different sizes and shapes on each board, including single and double-end socket wrenches, ratchet wrenches, and open-end wrenches.



Built on a discarded dolly, this handy tool carrier has space for as many as 75 different tools on both boards

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Knock-Out Traps Prevent Loss Of Costly Instrument Mercury

A MERCURY knockout pot, which can be attached to any instrument using the liquid, will prevent loss of mercury when excessive pressure differentials occur and automotically return the instrument to operation as soon as the excessive pressure is corrected.

Two knockout pots are installed, as indicated in Fig. 5, on each of the leads to the manometer and ahead of the valves on the leads. Connections to the pots are so arranged that any slugs of mercury blown from the instrument in either direction will enter the pot at right angles to its major dimension in an arrangement somewhat like that used on the familiar Toepler pump in the laboratory.

A connection from the bottom of the pot to the instrument lead returns entrapped mercury when the over-ranging condition ceases, readying the instrument for immediate service.

This arrangement saves mercury, eliminates taking the instrument out of service for replacement of mercury and possibly recalibration, and may avoid bringing a unit or line off-stream while the instrument is being restored to service—ordinarily a 30-minute job.

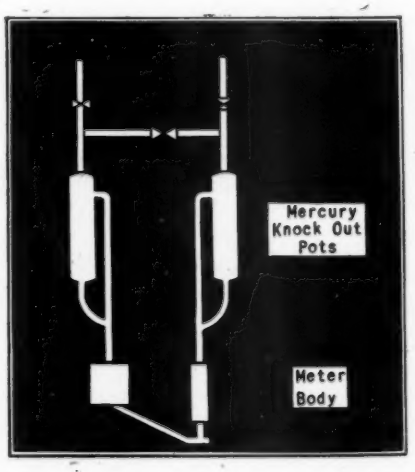

Fig. 5—Diagram of mercury dropout pot and installation on pressure or flow measuring instruments

Steam Connections Reduce Explosion Hazard

By J. A. GUYER, Phillips Petroleum Co.

TO LESSEN the possibility of explosions resulting from accumulated hydrocarbon vapors, Phillips Petroleum Co. has installed steaming-out connections on the starting air system at its gas plants and for Diesel engine installations.

Ordinarily in most plant air systems, samples taken for analysis will not indicate the presence of hydrocarbons, nor will there be indication of carbon monoxide or dioxide as evidence of the occurrence of combustion. However, such explosions have been known to occur, sometimes with disastrous effects. They are believed due to accumulation of hydrocarbon vapors in explosive mixture with the air. Coke has been found in the discharge piping of starting air compressors that could only have come from cracking of the lubricating oil after long periods of operation at relatively high temperatures.

Steaming-out connections have been installed on compressed air receivers, and are used periodically to clear these vessels of any accumulated heavy oil or vapor. In addition, safety (rupture) disks have been installed in the discharge line from the compressors and also at the air-receivers to lessen the hazard should an explosion occur.

It is realized that neither of these precautions will guarantee that an explosion will not take place. However, the steaming-out connection makes it possible to remove heavy oils that could, under proper temperature conditions which are proven can be reached, form an explosive vapor-air mixture. The blow-out-discs will relieve the pressure should an explosion occur and minimize damage to equipment.

In the several years in which steaming out has been practiced, no explosions have occurred.

Importance of Flexible Pipe Supports

AN

PAPER

By E. W. STOTHART
Manager Pipe Suspension Dept., Grinnell Co., Inc.

Presented before the Twelfth Mid-Year Meeting, API Division of Refining, St. Louis, June 2, 1947.

Transfer of weight in pipe hangers caused by thermal expansion of the piping at the high temperatures at which furnaces are operated today provides an important factor to be considered in the design and selection of supports. Equations are presented for calculating the additional stress caused by weight transfer. The importance is noted to the erecting and operating engineers of their being supplied by the design engineers of accurate and detailed specifications of proposed supporting systems for piping.

IT HAS been recognized by the engineering profession that total pipe stress is the addition of bending, torsional shear, longitudinal and circumferential pressure stresses. Yet, unless careful study is given to the design and selection of spring supports which will maintain a balanced pipe suspension system, the transfer of weight from one hanger to another will be the cause of an additional type of stress that warrants consideration insofar as the safety factor of the entire system is concerned. This paper will refer to this as weight transfer stress and will show its relative value compared to total pipe stress.

When a pipe suspension system is properly designed:

(I) The sum of the pipeline weights must equal the sum of the supporting forces, also—

The sum of the moments of piping weights acting at their centers of gravity and the supporting forces shall be equal to zero.

While it takes careful detailing and complicated calculations to satisfy these requisites, they are necessary in the selection of flexible supports.

The trend towards higher and higher temperatures has produced developments in flanged joints, valve design, expansion bends to provide a more flexible system, welding procedure and also metallurgy that make possible the operation of power and processing plants and refineries at up to 1100° F. or more. The real need for development in all of these fields was brought about by actual failure of some system or the calculation of certain stresses that would ultimately lead to failure.

The design of pipe hangers is often looked upon as simply a matter of adequate strength to hold the pipe in a fixed position. This is satisfactory for piping that operates at a constant or near room temperature. Since it is customary to assume that piping materials are at or near the same temperature as that of fluid or vapor contained in the system, we are faced with the problem of thermal expansion. Using the co-efficient of expansion for 1000° F., 100 linear feet of pipe would expand 9.4 in.

When this thermal expansion takes place, the resultant forces induced into the piping system are tremendous. The practice of using helical coil springs to allow this thermal movement to take place is quite general, but the care that goes into the design or selection of flexible supports is looked upon by many as a casual matter. In fact, many specifications covering the support of important high temperature piping will simply say, "spring hangers shall be provided." Merely to contend that this is a dangerous practice is not enough. A specific problem on the subject will let us see for ourselves the magnitude of this matter.

Let us assume that 90 ft. of API 5L, Size 10 in., Schedule 100 pipe is fastened between two fixed terminals and extending in three planes as shown in Fig. 1. To simplify the problem, let us further assume there is no movement of the terminals, and no cold pull in the pipe to reduce the stress factor, and also that hangers are selected to balance completely with the weight of the piping system as outlined in requirement (I).

When this system is heated to a service pressure of 775 psi gage and a temperature of 900° F., stress calculations show the maximum point of stress is located at Point *A* and that at Terminal *B* the bending and torsional shear stress is only about 200 lbs. less. By properly combining with longitudinal and circumferential pressure stresses we conclude that the maximum combined stress is 8093 psi.*

According to allowable "*S*" values taken from Table 22 for "Pipe in Oil Pipe System Within Refinery Limits" as shown in ASA-B31.1—1942, API 5L would have 18,000 "S" at 100° F. and 7000 "S" at 900° F. Section 6 of Fabrication Details, Par. 620—Sub-paragraph G will allow a combined stress of 18,750 "S"; however, Sub-paragraph H states that for temperature changes of a definite cyclic nature or for vibration they will only allow one-half of Sub-paragraph G or 9375 "S". A maximum combined stress of 8093 psi, as shown in Fig. 1 is well within the allowable limits.

As qualified in a preceding paragraph, these stress values assume that the piping system is fully supported. The determination of supporting forces is concluded in Fig. 2, and while no effort will be made to explain these calculations, the method employs a mechanical beam principle as prepared by E. Howarth and will be published in *Power Magazine*, July, 1947. A method for calculating weight balance is also available in literature published by the Grinnell Co., Inc.

With change in axial configuration of the piping system during the cycle of deflecting from cold to the hot position, it will be noted that the vertical shift at hanger *M*-3 is 2 5/16 in. up from cold to hot. In the event that the hangers provided for this example are of the Constant Support type, they will continue to support the entire weight of the piping and will have no effect on the total stress.

* Determining maximum combined stress in this paper employed the S. W. Spielvogel method.

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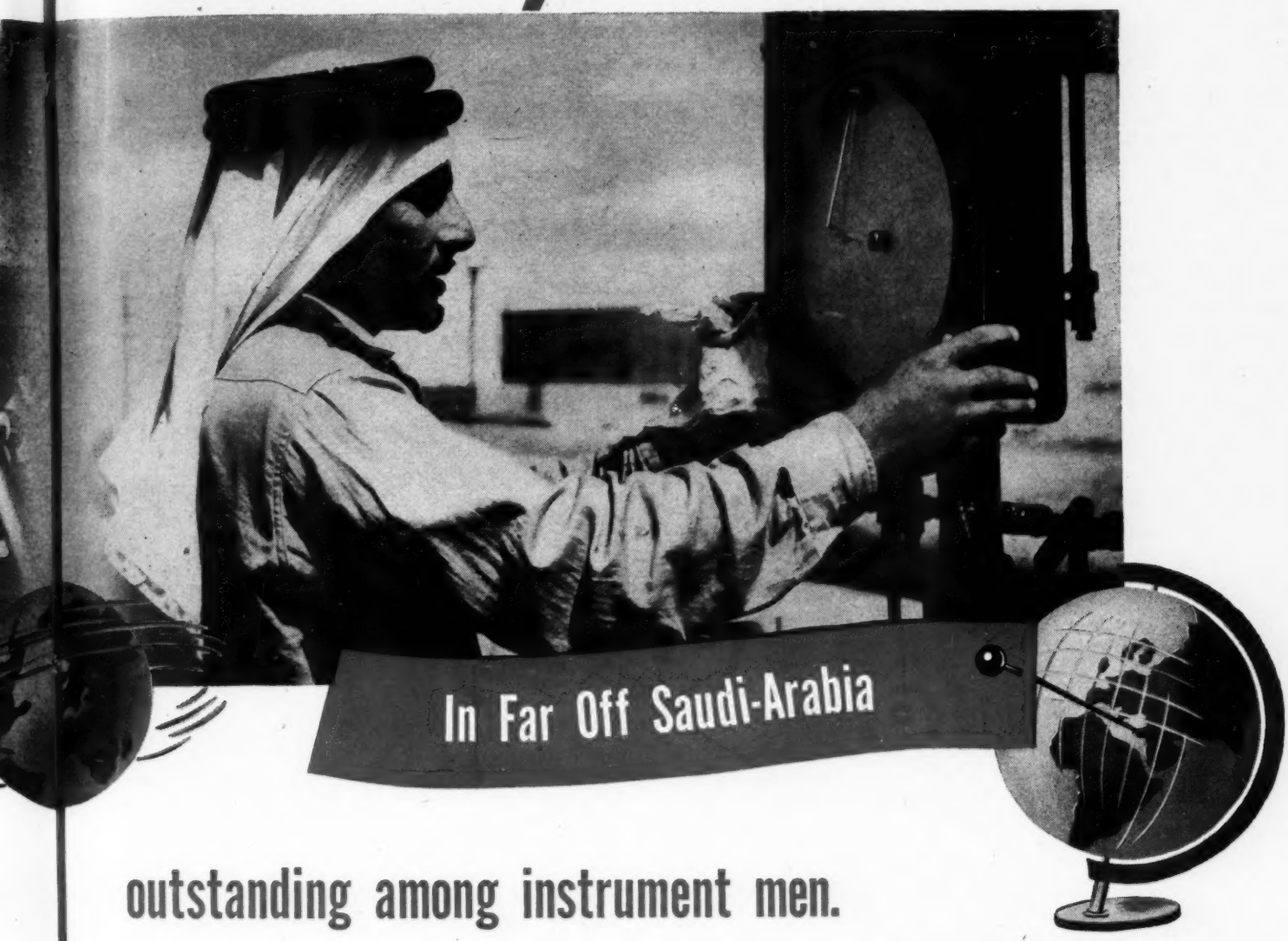

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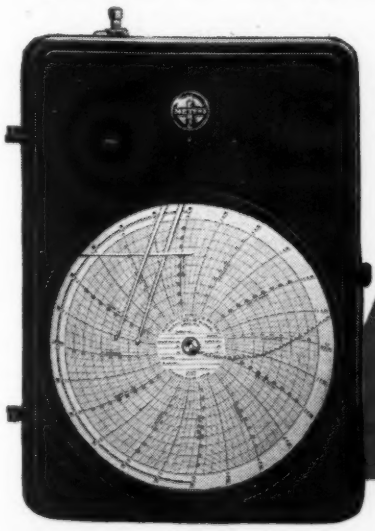

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In this type of hanger the spring forces are transmitted through a bellcrank lever that compensates for the variation in helical coil springs. Sometimes it is economical to make use of the Constant Support Type of hanger in order to hold within stress limits and avoid adding more pipe for flexibility as well as conserving the engineering time required to redesign the system.

However, when the usual type of helical coil springs are used for the supporting system, thermal deflection will cause a variation in the supporting forces. It is an inherent characteristic of helical coil springs that their forces vary in direct proportion to the deflection of the springs. It is always desirable to design a spring that will produce the least possible variation. Since the gravitational forces remain the same in either the upper or lower position of the system, any variation in the opposite reaction of the hangers will bring about a transfer of weight from one hanger to another.

A study of Fig. 3, which is a section of the stress illustration drawn in a single plane, will show the relative position of the piping in the hot and cold position.

W = Amount of Weight Transfer due to thermal expansion of the riser

(II) $W = \Delta K$

Δ = Amount of deflection in inches

K = Spring constant in psi.

It is generally considered to be a good spring hanger if the variability factor does not exceed 25% of the load per inch of deflection. Such a spring used in Fig. 3 would let W be equal to 2544 lbs.

In order to transpose this weight into terms of stress for addition into the total combined stress previously calculated in Fig. 1, the author is suggesting the following simple equation, considering the horizontal section of pipe acting as a cantilever beam.

S_w = Stress at fixed end due to weight transfer

(III) $S_w = \dfrac{[(W)\ (1)\ (D/2)]}{I}$ or

$$\frac{[(\Delta K)\ (1)\ (D/2)]}{I}$$

l = Length of pipe from hanger location to fixed end in inches

D = Outside Diameter of Pipe in inches

I = Moment of Inertia of Pipe

With this equation we find that S_w is equal to 2867 psi when S_w is combined vectorially with S_m we now have a total stress of 10,548 psi, which is well over the maximum allowed stress set forth in the code.

In addition to the foregoing technical

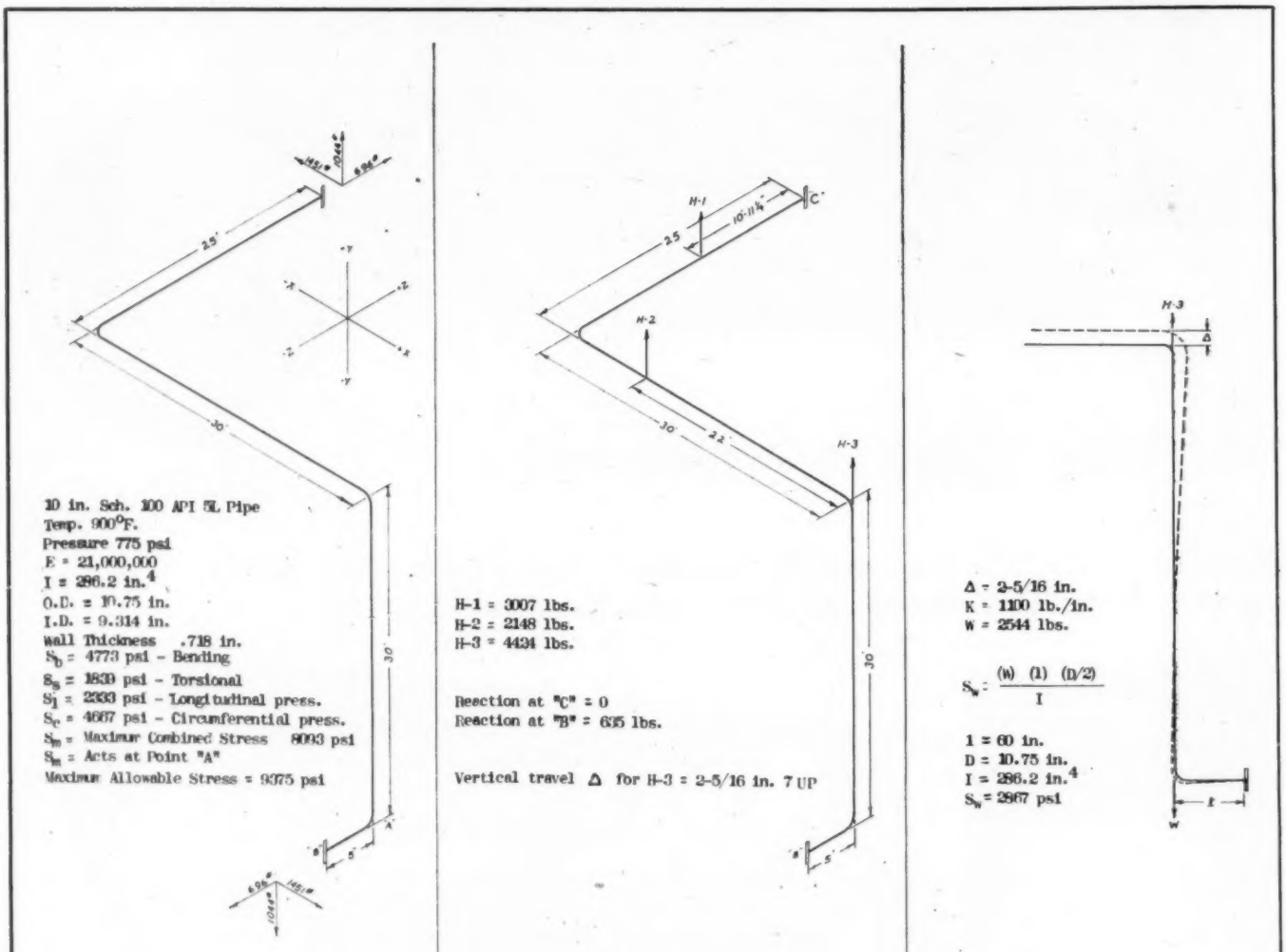
10 in. Sch. 100 API 5L Pipe
Temp. 900°F.
Pressure 775 psi
E = 21,000,000
I = 286.2 in.4
O.D. = 10.75 in.
I.D. = 9.314 in.
Wall Thickness .718 in.
Sb = 4773 psi - Bending
Ss = 1839 psi - Torsional
Sl = 2333 psi - Longitudinal press.
Sc = 4667 psi - Circumferential press.
Sm = Maximum Combined Stress 8093 psi
Sm = Acts at Point "A"
Maximum Allowable Stress = 9375 psi
H-1 = 3007 lbs.
H-2 = 2148 lbs.
H-3 = 4434 lbs.
Reaction at "C" = 0
Reaction at "B" = 635 lbs.
Vertical travel Δ for H-3 = 2-5/16 in. 7 UP
Δ = 2-5/16 in.
K = 1100 lb./in.
W = 2544 lbs.
Sw = (W) (l) (D/2) / I
l = 60 in.
D = 10.75 in.
I = 286.2 in.4
Sw = 2867 psi

Fig. 1—(left) Force and dimension diagram of conditions in supporting 90 ft. of 10 in. pipe, Schedule 100, API 5L. Fig. 2—(center) Determination of supporting forces for pipe shown in Fig. 1. Fig 3—(right) Relative positions of piping shown in preceding figures under hot and cold conditions

reasons for the selection of hangers that will protect the safety factors of the piping system, it has been the writer's experience in consulting with important engineering concerns over the U. S. and Canada that there are a large number of details that are often confused. Sometimes the details to which I refer may be perfectly clear to the designing engineer, nevertheless may be poorly specified and misinterpreted by the erector or operating engineer.

Setting Hangers Common Difficulty

Perhaps one of the most common difficulties concerns the setting of the hangers in the hot or cold position. As previously explained, when variable spring hangers are used, a deflection of the pipe causes a variation in the hangers' supporting forces. The fact that a drawing sometimes refers to a different load in pounds for the hot and cold position, obviously leads one to believe that the weight of the piping changes. Actually, the calculated weight of a piping system is the same in the hot as well as cold position. Weight means gravitational forces (downward). When Constant Support Hangers are used, the supporting forces (upward) are the same in both the hot and cold positions. The pipe weighs the same in its hot or cold position. When variable spring hangers are used, a deflection of the pipe means a variation in the (upward) supporting forces.

Another very common mistake is the result of drawings that specify "cold pull" or "cold spring." Let us again look at Fig. 3 and assume that we will cold pull the piping 50%. A 30 ft riser that expands 2 5/16 in. vertically may be cold pulled 1 5/32 in. by cutting the total length as "29 ft.-10-27/32." This does not mean that the flexible supports required for this section of pipe may be designed to accommodate a total movement of 1 5/32 in. only, but does mean that the co-efficient of expansion times 29 ft.-10-27/32 in. will deflect 2.308 in. instead of 2.3125 in. for the 30 ft. riser.

Sometimes an engineer may want to provide full support with variable springs in the hot position and have all of the variation occur in the cold position. The proper way to accomplish this without confusing the erector would be to specify the hot and cold setting of hangers on the drawings, or furnish the hanger fabricator with this information so that it may be die-stamped on the hanger prior to shipment.

Although a good erector can always deflect a spring hanger just the right amount to produce a balanced system in the operating or nonoperating position, since pipe stress is such a complicated mathematical problem, it should not be the erector's responsibility to make a decision in this matter. It is the engineering design of the hangers that will assure a safe piping system.

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Maintenance of Tubular Heat Exchangers

AN

PAPER

By J. G. HOUSMAN
Standard Oil Co. (Indiana), Whiting Refinery

Presented before the Twelfth Mid-Year Meeting, API Division of Refining, St. Louis, June 2, 1947

Special techniques and equipment developed through practical experience in a large refinery for the maintenance of tubular heat exchangers are described and illustrated. Mechanical cleaning is principally used; chemical and hydraulic methods have also been applied. Where deposits are water-soluble a simple hot-water wash with the exchanger left completely assembled has been successful. A graphical method has been developed to predict remaining exchanger life, based on actual measurements during disassembly correlated with maximum corrosion rate.

TUBULAR heat exchangers are an essential part of practically all units at the Whiting refinery. Exchangers are used as coolers, condensers, heaters, and reboilers. The fluids passing through these exchangers vary from very viscous, such as tar, asphalt, and crude, to light gases and vapors such as naphtha vapor, hydrogen and steam. The frequency and extent of maintenance on a particular exchanger is largely dependent on the service of that exchanger. Service is defined as (1) fluid combination, (2) temperature level and temperature differential, (3) pressure level and pressure differential, and (4) velocities of the fluids. Of these, the fluids and their ever-present contaminations are undoubtedly the most important and dominant factor.

A wide variety of material is used for the various parts of the exchangers, the more common ones being carbon steel, admiralty metal, chromium-molybdenum alloy steel, and high chrome-nickel stainless steel type alloys. The material selected originally is one which will withstand the anticipated type of corrosion, but occasionally a material change is made after some use. Such a material change is the result of unexpected or unusual corrosion or a change in the service of the exchanger.

Carbon steel is used most widely and where the corrosion rate is relatively low, in general, of the order of 0.01 in. per year or less. Admiralty metal tubes are used in exchangers having water as one of the fluids. Its use greatly reduces scale formation on the water side and hence reduces the frequency of cleaning. Chromium-molybdenum and chromium-nickel alloy steels are used where corrosion cannot be satisfactorily reduced to permit economic use of carbon steel.

Basis for Maintenance

Removal of an exchanger from service for maintenance is regulated by the operating departments and the inspection department. Basis for removal may be (1) excessive pressure drop, (2) sufficient loss of efficiency to affect operation of the unit, (3) contamination due to leakage, (4) excessive external leakage, and (5) expected life based on previous records. Excessive pressure drop and loss of efficiency are the result of fouling, whereas contamination is generally the result of corrosion. However, contamination and external leakage, and especially the latter, may be due to mechanical defects such as gasket leakage or leakage between the tubes and tube sheet resulting from faulty tube rolling. Past performance records, either with respect to fouling or corrosion, in many cases provide an accurate means of determining the necessity of maintenance work.

When a number of exchangers are arranged in series, the efficiency loss of the entire group does not provide specific information as to the troublesome exchanger. By checking the pressure drop across each exchanger, those requiring cleaning can be determined. For example, the pressure drop across an exchanger may increase from 6 psi when clean to 70 psi when very dirty. In the case of a single exchanger, the efficiency loss is generally sufficient to determine the extent of fouling, but this is not always true. For instance, some exchanger service results in concentrated fouling only at one section, usually near the inlet or outlet. Therefore, the over-all heat transfer is not appreciably affected, but the pressure drop may be materially increased. With an exchanger in this condition, erosion may result due to localized high velocities.

In one case at the Whiting refinery, a hole was eroded through the shell in the vicinity of the drain notch at the bottom of a baffle after the entire cross-section of a pass was solidly plugged in this area except for a passage through this drain notch. Also excessive pressure drop may overload the existing pumping equipment. Therefore, in general, the pressure drop across the various ex-

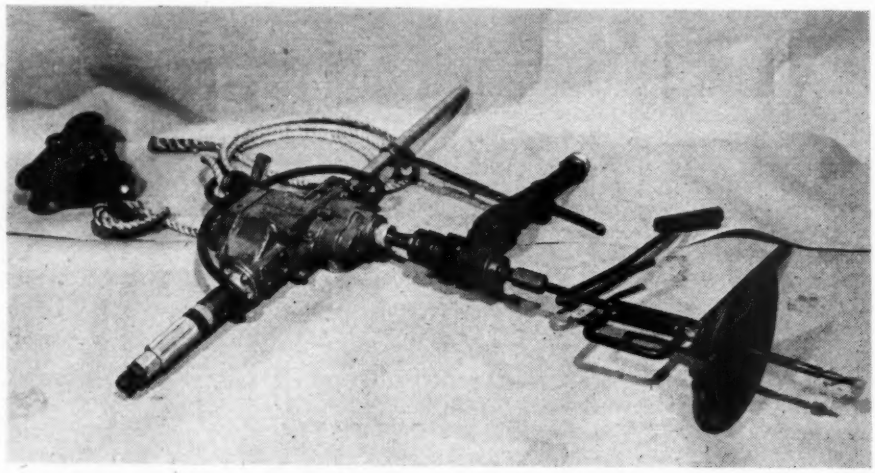

Fig. 1—Mechanical drilling equipment used in cleaning heat exchangers

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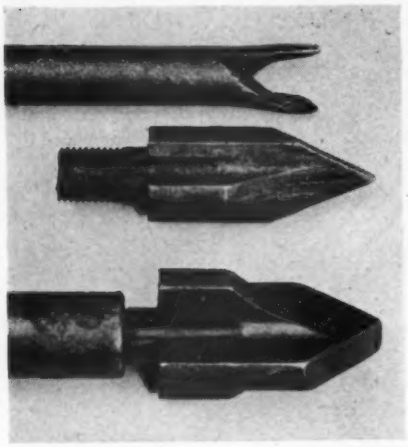

Fig. 2—Drills used for cleaning heat exchangers

changers on a unit is periodically determined and recorded.

Contamination may or may not be serious, depending on the two fluids passing through the exchanger. For example, some leakage of crude into a reduced crude stream is not objectionable, but leakage of any substance into a semi-finished product stream results in an immediate removal of the exchanger from service. In some cases contamination is premitted until the capacity of the pump or other mechanical equipment is affected.

Disassembly Problems

A persistent source of trouble, in the disassembly of our exchangers has been unbolting the external flanges. With an exchanger using large and relatively few retaining bolts, it is often very difficult to supply sufficient force to break the nuts loose. The impact wrenches available for this operation are frequently inadequate. It has been the experience of our maintenance department that a larger number of small diameter retaining bolts is much more desirable than the larger and fewer number of retaining bolts. A wide variety of bolt lubricants have been used in the past with the most common one being a mixture of graphite and high volatile oil. However, recently a colloidal copper coating has been used with improved results.

The removal of the tube bundle is very difficult if heavy deposits exist on the shell side of the exchanger or if the baffles bind on the shell due to warpage of the tubes. Normally, the bundles are pulled by the use of a chain fall. If sufficient force cannot be applied in this manner, mechanical or hydraulic jacks are used against the floating tube sheet to supply the required additional force. These jacks are arranged so as to act between the floating tube sheet and the shell with a large wood cushion block placed against the tube sheet for protection against localized damage. In several cases even this combination of effort has not been sufficient to move the bundle. However, by removing the insulation from the outside of the shell and then striking the shell with heavy mauls, coincident with the application of the maximum permissible force, it has been possible to "inch" the bundle out of the shell.

Cleaning Methods

Mechanical cleaning has been in the past and still is the primary method of cleaning heat exchangers at the Whiting refinery. If the shell side is relatively clean, but the tube side requires cleaning, it is not necessary to pull the tube bundle, but only to remove the channel cover, the shell cover, and the floating head cover. Steam, water, air, and mechanical drilling are used to clean the tubes depending on the type and amount of deposits, with mechanical drilling the basic operation. The drilling equipment, shown in Figs. 1 and 2, consists of an air motor, a spindle, a hollow shaft the length of the tubes, and an attachable drill.

The drill used at present is a commercial product, but in the past the end of the tube was simply ground to provide a cutting edge as shown in Fig 2. A monorail is erected parallel to the tube bundle to support the air motor, spindle, tube and drill assembly. Air, water, or steam is transmitted through the spindle and the hollow shaft to carry the deposits out of the tube as the drilling progresses. The funnel shaped shield, through which the hollow tube extends, protects the operators from the dirt which is blown out of that end in the event of a plugged tube. After completion of the drilling, the inside surfaces of the tubes are usually sandblasted.

For mechanically cleaning the shell side of the exchanger, it is necessary to remove the tube bundle. The bundle is generally cleaned immediately outside of the shell while resting on a permanent or temporary platform. If the deposits are concentrated and cannot be removed by a water or steam wash, large "saws", shown in Fig. 3, are used to remove the major portion of the deposits. These "saws" are made from soft sheet metal and are of sufficient length to pass through and extend beyond the bundle. The main difficulty with this method occurs when attempting to remove gummy deposits since these deposits tend to accumulate on the inaccessible portions of the inner tubes. The inside of the shell is cleaned by sandblasting.

The cleaning of exchangers has not been confined entirely to mechanical methods. Chemical and hydraulic methods have been tried with fairly good success. The most successful has been a simple hot water wash with the exchanger left completely assembled. Of

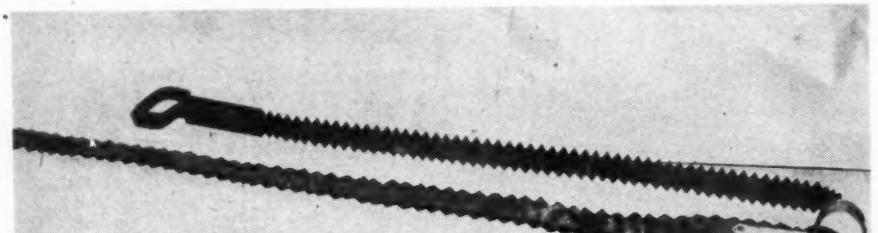

Fig. 3-Sheet metal saws used for cleaning the shell side of the tube bundle

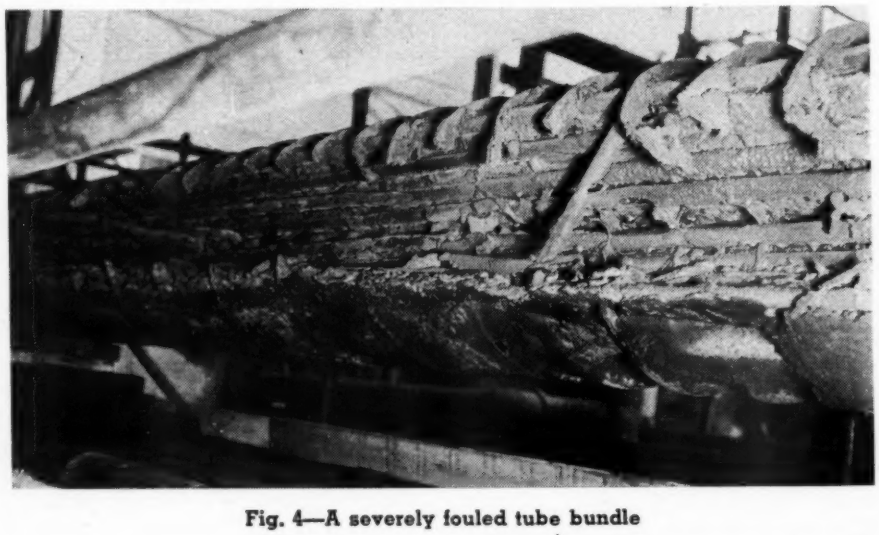

Fig. 4—A severely fouled tube bundle

Fig. 5—Heavy deposits on the shell side of a tube bundle in exchanger in toluene unit

course, this method is limited to deposits which are water soluble.

Extensive fouling consists primarily of salt or coke deposits. The salt deposits occur almost exclusively during the preheating of crude. These salts remain in solution until the crude reaches the vicinity of 300° F. As the temperature rises, increasing amounts of salts are deposited in the passages. Thus, when a group of exchangers are in series and used to preheat crude, the worst fouling generally occurs in the last exchanger.

Desalting equipment is being or has been installed on units which formerly did not require such equipment. For example, from May to September, 1944, a mixture of Mid-Continent and West Texas crudes containing about 17% of the latter, was processed in our No. 370 combination cracking unit. The crude was not desalted and, even with the low percentage of West Texas crude, the fouling of the higher temperature crude exchangers increased to such an extent that this method of operation was abandoned until desalting equipment could be installed. The corrosion rates also showed a marked increase during this period of operation. Examples of severely fouled heat exchanger tube bundles are shown in Figs. 4 and 5.

Inspection

All exchangers which are partially or completely disassembled are inspected by the inspection department. The inspection consists of a visual check, physical measurements and, when found necessary, magnaflux examination. The use of magnaflux examination has been confined to the inspection of welds. The extent of the physical measurements depends to a large extent on the visual check. In cases of a complete disassembly, however, all of the component parts are at least spot checked, primarily as a basis for determining corrosion rates. Fig. 6 illustrates a graphic method used for this determination. In general, a large number of measurements are made and the maximum corrosion rate is used to predict the remaining life. After the inspection the corrosion rate for each exchanger is revised and the expected life predicted.

A report on all such inspections is issued covering the general condition, corrosion rates, expected future life, and repairs or replacements recommended. After a number of inspections have been made on a particular exchanger, these inspection reports constitute a reliable basis for determining frequency of cleaning, expected life of each part of exchanger, and desirable material changes.

Repairs

All minor repairs on exchangers are performed in the field. Field work includes rerolling leaky joints, various minor welding repairs, plugging leaking tubes with solid tapered plugs, and the replacement of removable parts.

When a major repair is required, such as completely or partially retubing a bundle or remachining gasket surfaces, the parts concerned are removed from the unit for repair in the machine shop. Facilities for remachining a gasket surface of a tube sheet with the tubes intact are planned for our machine shop, but at present this work on a tube bundle is performed by outside shops.

Reassembly

The reassembly of exchangers is relatively trouble-free since the shell and tube bundle are clean, and interference between the baffles and shell can be removed by grinding the baffles. However, gasket leakage is occasionally found during the hydrostatic test. In most cases it has been found more satisfactory to reuse the gaskets if they are in good condition than to replace them with new ones. The asbestos-filled gaskets are sometimes preferred over the solid soft steel and straight asbestos gaskets. However, all three types have been used.

Conclusion

There are an unlimited number of problems connected with any maintenance program, and certainly the one covering tubular heat exchangers is no exception. In this paper only the most common problems and the most general maintenance procedures are covered briefly. Although corrosion is one of the foremost causes leading to heat exchanger maintenance in any refinery, it has only been briefly mentioned here because it in itself is a major subject for discussion.

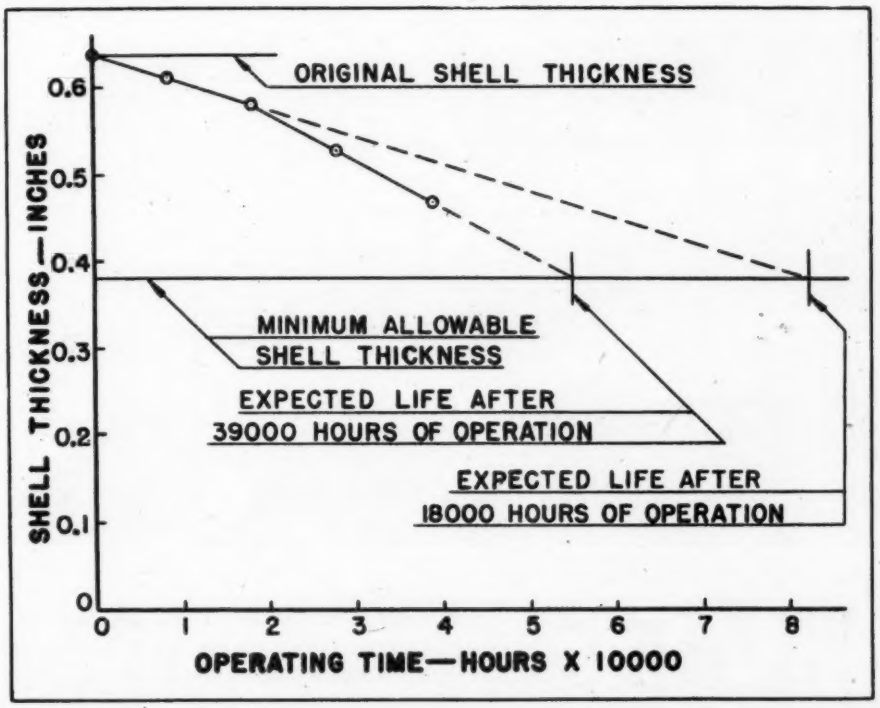

Fig. 6—Graphical method used to predict remaining life of exchangers

Thoroughness and efficiency throughout are characteristics of McKee refinery design and construction as shown in this main pump house and manifold.

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DESIGN, ENGINEERING AND CONSTRUCTION FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

UNDIVIDED RESPONSIBILITY IN ONE ORGANIZATION

New High Efficiency Column Based on Increasing Rate of Diffusion of Gas Molecules

A NEW rotary concentric-tube laboratory distilling column, having a very high efficiency factor for fractional distillation, has been developed at the National Bureau of Standards.

The new column was designed to improve separating efficiency by increasing the diffusion rate of the molecules in the gas phase. This is accomplished by forcing the gas into turbulence through rotation of the inner closed cylinder in a concentric-tube rectifying section.

The apparatus, shown in Fig. 1, consists of three parts—the Pyrex head, steel rectifying section, and Pyrex pot. All three sections are provided with external heating elements and copper-constantan thermocouples for temperature regulation.

The steel rectifying section of this distilling column is the empty annular space, 0.043 in. (1.09 mm.) wide, formed by the inside surface of a stationary outer cylinder and the outside surface of a rotating closed inner cylinder, 2.928 in. (7.44 cm.) in outside diameter and 23.0 in. (58.4 cm.) in length. A motor-and-pulley system drives the rotor at speeds up to 4000 rpm. The outer cylinder is enclosed in an asbestos-covered metal heating jacket surrounded by three separate nichrome heating elements for the top, middle, and bottom portions of the jacket, respectively. The heating elements are covered externally with magnesia insulation and a layer of aluminum foil.

The Pyrex glass head consists principally of a water-jacketed condenser directly above and opening into an electrically heated chamber, in which the liquid reflux may be collected and sampled by means of a glass valve. The heated chamber is surrounded by asbestos wool insulation and aluminum foil.

The pot, made of a three-inch Pyrex pipe, is sealed at one end and provided with a butyl carbitol manometer and a tube for withdrawing samples. Heated externally by a Glas-col special sleeve type heater, it is surrounded by magnesia insulation covered with aluminum foil.

Three thermoelements are provided. One measures the difference between the temperature of the top portion of the rectifying section and the liquid-vapor equilibrium in the head. Another measures the difference between the temperature of the middle portion and the mean temperature of the top and bottom portions of the rectifying section. A third is used to determine the difference between the temperature of the bottom of the rectifying section and the temperature of the liquid in the pot.

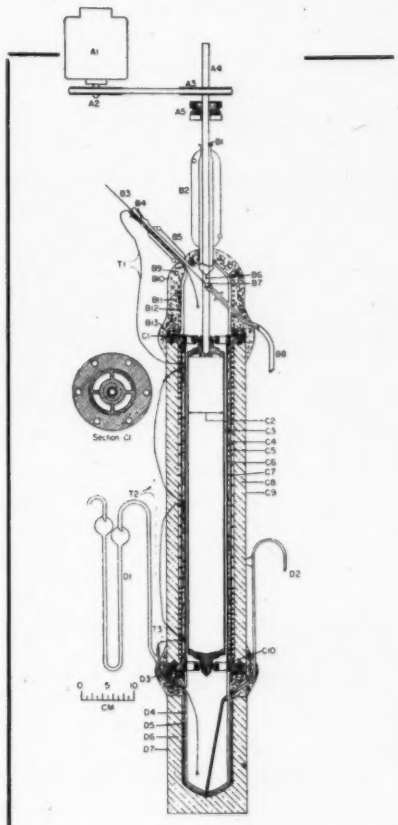
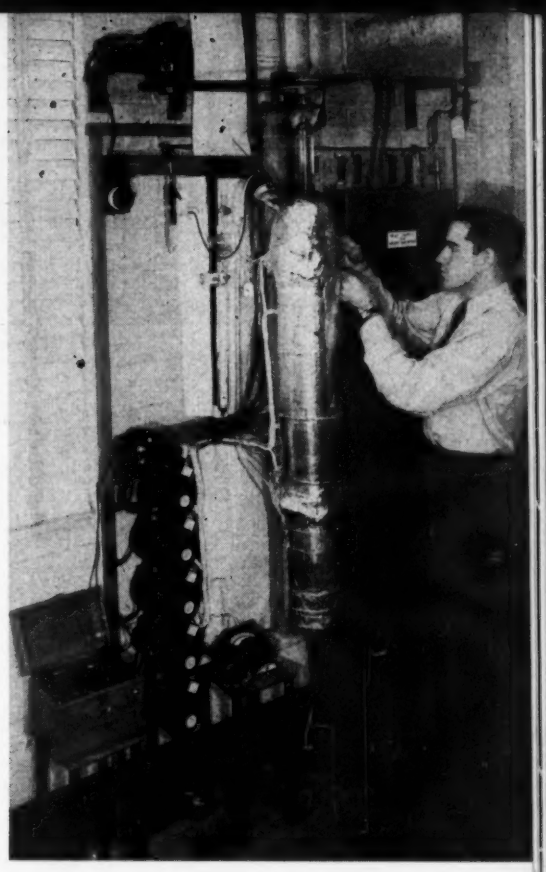


Fig. 1—Schematic diagram of high efficiency distilling column. A1, A2, A3, A4, and A5 are parts of the motor assembly for rotation of the inner column. Principal parts of the head B are: head condenser B2 with water jacket; control B3 for valve B7, used for sampling liquid reflux in head; side condenser B5; glass rod B6 to direct flow of liquid reflux onto valve; outlet B8 for head sample; thermal insulation B9; aluminum foil B10; and nichrome heater unit B12. The steel rectifying section C consists of the cylindrical rotor C2, concentric with the open tube C4; the nichrome heating elements C7; thermal insulation C8; and aluminum foil C9. The more important parts of the pot D are the butyl carbitol manometer D1; the tube D2 for withdrawing samples of material and the pot heater D5



Laboratory technician removing a test sample of distillate from the new distilling column in the Bureau of Standards' distillation laboratory

For high values of throughput—two to four liters of liquid per hour—this distillation column, when operated at 4000 rpm, has an efficiency factor about ten times those previously reported for other rectifying columns. The efficiency factor changes relatively little with throughput at a given speed of rotation, but increases markedly with speed of rotation. This column also has low values of pressure drop per unit throughput, which may be quite advantageous for distillation at low pressure.

The new distilling column was developed in the Bureau's laboratories by Charles B. Willingham, Vincent A. Sedlak, James W. Westhaver, and Frederick D. Rossini, in connection with the cooperative research program on hydrocarbons sponsored jointly by the Bureau and the American Petroleum Institute.

The program of the Bureau and the API has two objectives: (1) the investigation of the chemical constituents of the crude oil based upon the actual isolation of pure hydrocarbons, and (2) the securing of high-purity standard samples for the calibration of instruments used in analyzing such complex mixtures as aviation fuels and synthetic rubber components.

The new distilling column, which is expected to have wide application to fractionation processes, will aid materially in this research program.

Patent Trends in Petroleum Refining

By Peter J. Gaylor

Patent Attorney and Editor "The Technical Survey"

Developments disclosed in the patents reviewed below include:

Automatic maintenance of adiabatic conditions in a fractionation system.

Homogenizing apparatus for removing mercaptans from naphthas.

A new lubricant in which a stabilizing agent, bentonite, is used to maintain castor oil and petroleum oil in the form of an emulsion.

Provides Automatic Adiabatic Separation

A FRACTIONATION system having automatic means for maintaining adiabatic conditions to effect the separation of otherwise difficultly separable mixtures is described in patent U. S. 2,416,404 issued to Standard Oil Co. (Indiana). By use of the system, it is claimed that smaller amounts of reflux are needed and increased efficiency is obtained in the separation of narrow-boiling cuts.

One mode of operation is illustrated in Fig. 1 (a). Hot feed enters at 21, the lighter constituents of the vapor ascending through column 10 and undergoing fractionation at the same time, while the heavier constituents accumulate as bottoms at 13. Simultaneously, heat is applied to reservoir 13 and the vapors generated rise in jacket 12 and provide an insulating envelope of vapor about the column 10 at a temperature about the same as that within column 10. Concurrently, some of the vapors enter column 10 through open bottom 25.

By suitable throttling of valve 26, controlled amounts of vapor are continually removed from shell 12 and condensed to keep the space between column 10 and shell 12 completely filled with vapor. Light ends accumulated in the upper portion of shell 12 are withdrawn through valve 26, condensed in 15 and recycled via line 16, while non-condensibles are withdrawn through line 17.

In this way, column 10 suffers no heat loss and, in fact, a slight heat influx is possible by controlling the amount of reflux introduced into column 10 and/or the condensation occurring in shell 12.

The narrower the cut being fractionated, the more efficient the column becomes, since its overall temperature then approaches a constant and thus approaches ideal adiabacity. Thus, the unit is particularly adapted to fractionate mixtures such as isomeric butenes, heptane-toluene, and toluene-xylene cuts.

In Fig. 1 (b), inner column 10 and outer shell 12 are provided with packing 11 and 11a. The hot mixed feed enters through 21. The vapors recovered from the inner column 10 at 22 are condensed in 33 and recovered through line 35, while a portion is recycled as reflux through line 36. Vapors from shell 12 are drawn through line 14, condensed in 32 and recovered at 40, while a fraction is returned through line 38.

Fractionating column 10 is substantially adiabatic and the product recovered may be free of contaminants, making it possible to fractionate, in one operation, a whole naphtha, to obtain a light naphtha and a heavy naphtha, with simultaneous removal of heavy color-producing bodies. The apparatus shown in Fig. 1(b) may also be used in separating azeotropic mixtures, the azeotropic agent being introduced through line 21.

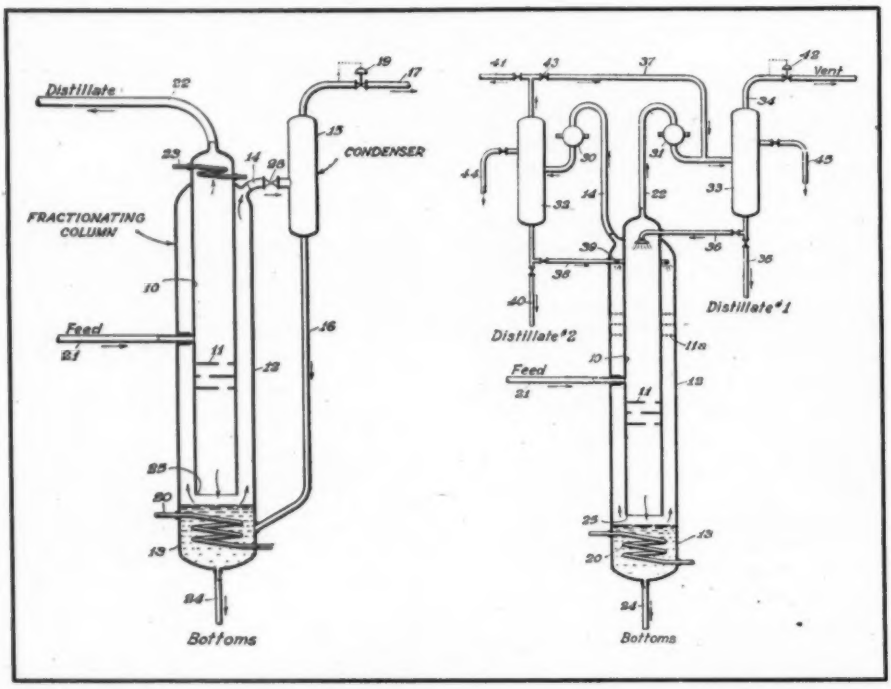


Fig. 1—(a) left, (b) right—Two methods of operation of fractionation system having automatic means for maintaining adiabatic conditions

Homogenizing Apparatus For Removing Mercaptans

THE efficiency of light oil treating methods can be materially increased by effecting an intimate dispersion of one phase in the other by mechanical action wherein an unstable emulsion is formed which breaks quickly to insure adequate separation of phases. In U. S. 2,420,544, issued to Standard Oil Development Co., the mechanical action employed involves mechanical dispersion of the oil with the treating agent, by effecting a shearing action, as a result of which the two phases break down into microscopically fine particles which are thoroughly mixed with each other to achieve a closer equivalent of a theoretical stage than in conventional contacting methods.

This is achieved by the use of an apparatus such as that shown in Fig. 2. Naphtha is introduced through line 1 and treating agent, such as caustic soda,

TABLE 1—Extraction of Mercaptans from Naphtha with Various Reagents by Batch Agitation and by Homogenization

Column Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stock and Procedure	Untreated Original Naphtha	Treated with Sodium Hydroxide 11.2° Bé				Treated with [2] Potassium Hydroxide 12.9° Bé				Treated with Potassium Hydroxide, 6N, 29.6° Bé				Treated with Solutizer Solu. 3N Potassium Isobutyrate, 6N Potassium Hydroxide			
		Batch Treat[1]	Batch Treat[1]	3000#/ Sq. In. Homog-enization		Batch Treat[1]	Batch Treat[1]	3000#/ Sq. In. Homog-enization		Batch Treat[1]	Batch Treat[1]	3000#/ Sq. In. Homog-enization		Batch Treat[1]	Batch Treat[1]	3000#/ Sq. In. Homog-enization	
Operating Conditions:																	
Per cent Treat	...	10	20	9.9	18.4	10	20	9.9	26.4	10	20	10.9	18.4	10	20	12.9	25.0
Treating Temp., ° F.	...	80	80	75	75	80	80	75	77	80	80	80	80	80	80	82	82
Gasoline Inspections:																	
Doctor Test	[3]DNP	DNP	DNP	DNP	DNP	DNP	DNP	DNP	DNP	DNP	DNP	DNP	DNP	DNP	Pass	Pass	Pass
Mercaptan sulfur, mg./100 ml	20	6	3.5	4.5	3	6	3	4	2.5	3.5	2.5	2.5	2	1	0.5	0.5	0.0
Per cent Mercaptan Removed	...	70.0	82.5	77.5	85.0	70.0	85.0	80.0	87.5	82.5	87.5	87.5	90.0	95.0	97.5	97.5	100
Reactive sulfur, mg./100 ml	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Peroxide Number	0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gravity, ° API	52.9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Dist., Naph.—																	
I. B. P., ° F	130	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
212	21.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
302	62.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
392	94.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
F. B. P., ° F	421	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Per cent Recovery	98.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Per cent Loss	0.4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

(1) Three minutes vigorous agitation in the presence of nitrogen.
(2) Equivalent to sodium hydroxide solution (11.2° Bé.) in "OH" concentration.
(3) DNP=does not pass.

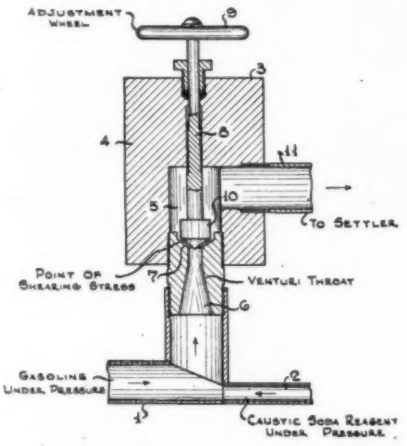


Fig. 2—Homogenizing apparatus for removing mercaptans from naphtha

is introduced through line 2 and the two are mixed and pumped into homogenizing valve 3, consisting of block 4 having bore 5 acting as a discharge space from venturi 6. Clearance between valve seat 10 and venturi outlet 7 determines the amount of shearing stress imposed upon the liquids forced through. This clearance is adjusted by turning valve stem 8. A discharge pressure of 3000 psi has been found suitable for treating naphtha with caustic.

Table 1 tabulates results obtained in this manner, in comparison with batch treatments in a separatory funnel, using 3-minute vigorous agitation by hand shaking. It will be seen that, in all cases, homogenization gave better mercaptan removal than did batch agitation. When the results are plotted on a curve so as to obtain exactly equivalent percentage treats, the improvement corresponds to an increased mercaptan removal up to 10%. The greatest significance of this incremental improved efficiency of extraction appears in columns 14, 15, 16 and 17 of the table, which were obtained when using a caustic solution containing a solutizer. For a 10% treat batch agitation did not give a product passing the doctor test, while essentially a similar percentage treat by homogenization did give a sweet product.

The process is also applicable to solvent extraction, absorption of olefins, etc.

New Lubricant of Castor Oil and Petroleum Oil

THE production of a grease-like lubricant having high load-carrying properties and relatively low shear values at low temperatures without flowing away from bearing surfaces at high temperatures, has been described by Crane Company in its U. S. 2,412,929.

The lubricant relies upon the mutual insolubility of castor oil and petroleum oil for its effectiveness. The two oils are maintained in the form of an emulsion, stabilized by bentonite or other non-metallic solids. When the total amount of oil in any one of these emulsions is no greater than that accounted for by the oil absorption value of the solid material, the dispersions have a putty-like consistency and are apparently stable. When the total amount of oil is greater than that accounted for by the oil absorption value of the solid component, all of the resulting emulsions are unstable. In the case of bentonite mixtures, however, the compositions are more unctuous and separate more slowly than mixtures containing primarily other clay minerals as the solid ingredients.

Stabilization of such mixtures is further facilitated by the addition of triethyl or tributyl phosphate, possibly because of the fact that these esters may be mutually soluble in both oils. Complete stabilization is effected by the addition of a fifth component, a solid such as lithopone. When this material is added in the critical minimum amount, there is a sharp change from a consistency similar to that of a thick paint, to that of a grease, and the mixture no longer flows.

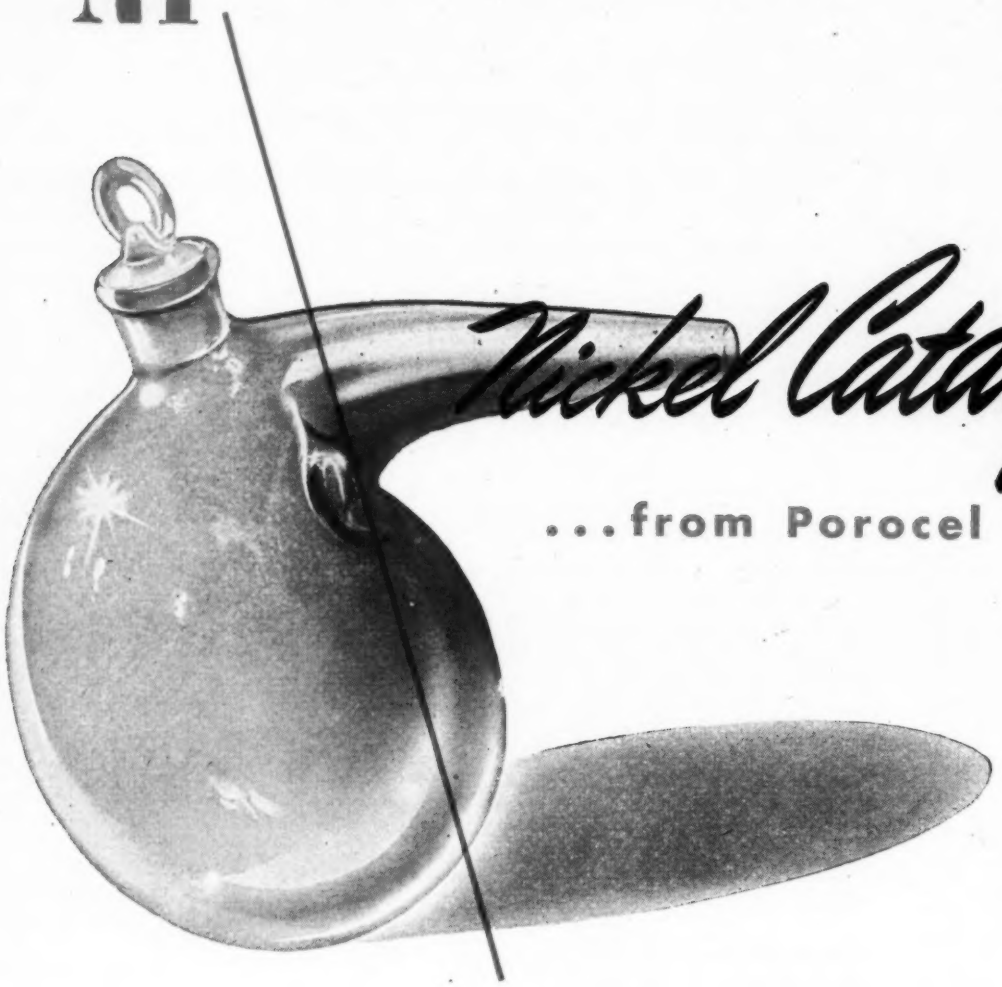
The following formulas are typical of the mixtures with which work has been done:

	Formula 1	Formula 2
Castor oil	22	22
Petroleum oil	22	22
Bentonite	27.5	37
Lithopone	27.5	17
Triethyl phosphate	1	2
	100	100

Selected Patents of the Month

U.S. 2,419,997 (Houdry Process)—Catalytic dehydrogenation of aliphatic hydrocarbons.
U.S. 2,420,030 (S.O.D.)—Cyclopentane-isopentane-branched hexane production.
U.S. 2,420,082 (Standard Oil Development)—Asphalt with methacrylate polyester.
U.S. 2,420,122 (Univ. Oil Products)—Metal deactivator.
U.S. 2,420,129 (Univ. Oil Products)—Controlling flow of fluidized solids and liquids.
U.S. 2,420,145 (Univ. Oil Products)—High temperature conversion.
U.S. 2,420,185 (Phillips Petroleum)—Asphaltic materials.
U.S. 2,420,233 (A. Boake, Roberts & Co. Ltd.)—Viscosity increasing Al salts for oils.
U.S. 2,420,244 (Pure Oil)—Naphthenic acid recovery.
U.S. 2,419,997 (Houdry Process)—Catalytic dehydrogenation of aliphatic hydrocarbons.
U.S. 2,420,328-9 (du Pont)—Lubricant for processing metals.
U.S. 2,420,369 (Texas Co.)—Alkylation of isoparaffins.
U.S. 2,420,386 (Texas Co.)—Reduction of corrosion of Friedel Crafts catalysts.

Ni



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Increased Life of Lead-Lined Tanks By Revised Method of Fastening

In addition to the method for lead-lining of tanks described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have recently been issued includes:

- **Continuous analyzer ups efficiency of fractionator**
- **Barrel stand tray allows for different dispensing positions**
- **Scraper removes clogging in gas-jet feed injector**
- **Gas-tight downcomer will fit variations in column diameter**

DISPENSING WITH the conventional fastening method using bolts covered with patches, a technique for lining vessels with lead insures a smooth surface which will not buckle, pull apart, and leak due to stresses and strains during the handling of various strengths of weak sulfuric acid at the temperatures necessary for recovery of concentrated acid.

The uneven surface caused by the bolt method is also undesirable when it is considered that it is common practice also to line the lead-lined tank with acid-resisting brick. The new method is illustrated in Figs. 1, 2, and 3, showing its application to an open-top tank having both cylindrical and conical sections.

The slots 12 are cut into wall 11, spaced at regular or staggered intervals. Angle irons 13 are attached to the shell on the outer wall at points adjacent to the top and the lower edges of slots 12. The lead lining 16 on the wall of the vessel is supported by lead blocks 17 burned to the lining and rested on angle iron 13. The lining is held tightly against the wall by lead sheets 18 also burned to blocks 17, which extend through the slot and lap over and around the angle iron, as seen in Fig. 3.

The conical bottom is also covered with lead sheet lining 16, which in turn is covered with brick lining 21, protected at the corners by lap joint covering 22, also made of lead. Additional slots 12 are cut into the bottom section.

The fastening method in the bottom consists of burning a plate of lead 24 to the lining 16 through the slots, as shown at right in Fig. 2.

In a specific job wherein the method described was used, the vessel to be lined was 29 ft. in diam. Angle irons 13 were installed at about 2 to 3 ft. intervals around the circumference. Slots 12 were 4 in. high by 12 in. wide, and were staggered around the shell at about 3½ ft. intervals. The lining was a 16 lb. lead. Similar sized slots were cut in the conical bottom at radii of about 7½, 11½, and 12½ ft. from the apex at staggered intervals.

U. S. 2,420,038, issued May 6, 1947, to Frank A. Ferguson, assignor to Standard Oil Development Co.

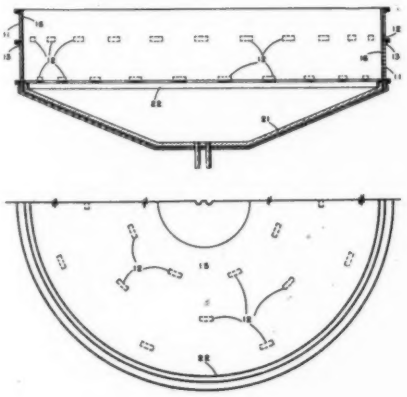


Fig. 1 (Above) — Elevation and plan view of cone-bottomed, cylindrical tank using improved method for securing lead lining (U.S. 2,420,038)

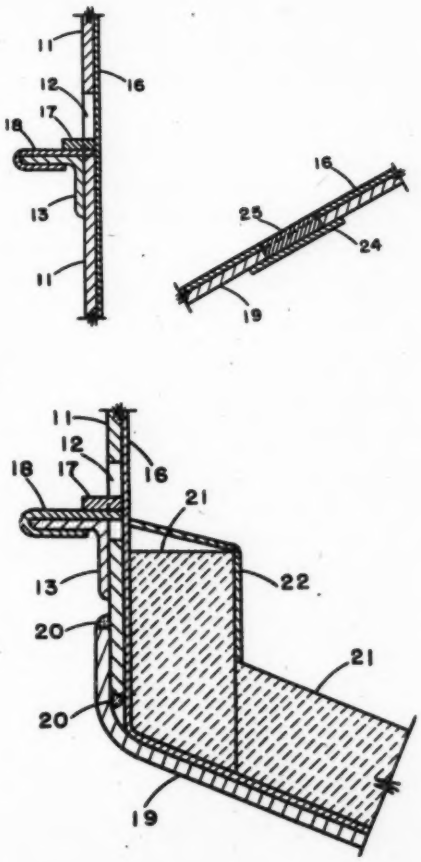


Fig. 2 (Above right)—Left, details of fastening method through slots in side wall; right, in bottom

Lapping the lead over protects corner joints

Improve Fractionator Efficiency With Continuous Feed Analyzer

CONTINUOUS ANALYSIS by spectrophotometer of fractionator feed coupled with control for varying the point of feed entry improves the efficiency of a distillation column.

Advantages claimed are: (1) it enables the attainment of high degree of separation by having feed entry at the optimum position at all times, (2) permits the use of a lower quantity of reflux, (3) eliminates or greatly reduces the size of the feed surge tanks, and (4) permits use of smaller diameter column.

In operation, a small stream is taken from the main feed line and passed continuously through the analyzer. Impulses of varying degrees are transmitted from the analyzer to a solenoid valve manifold where it transfers to a compressed air line for control of the air motor valves at the several feed points on the fractionator.

The instrument includes the use of conventional devices for compensating for lag and for sudden variations which are too short-lived to materially affect the end product.

Originally developed for use in butadiene recovery from the effluent from the dehydrogenation of normal butene, the equipment is said to be adaptable to other process equipment.

U. S. 2,419,528, issued April 29, 1947, to John Biegel, assignor to Phillips Petroleum Co.

Barrel Stand Tray Adjustable To Various Positions of Drum

AN EASILY-MANEUVERED drum or barrel stand includes a tray mounted on the base which can be adjusted to variations in the dispensing position of the barrel.

As shown in Figs. 4 and 5, the drum stand itself is of simple design, embodying base 3 and cradle straps 13 in which the drum rests, held in place by straps 14. These straps are connected to the pivoted support 15 which is set so as to rotate in the bearing formed by frames 5.

The construction of the base 3 permits tilting the drum from an up-ended position to a horizontal dispensing position, as shown in Fig. 5.

Adjustable tray 29 is mounted on a pin which fits into hole 28 on the frame 3. It can be rotated to any position, two of which are indicated by the dotted outlines in Fig. 6.

U. S. 2,419,786, issued April 29, 1947, to Donald E. Meehan, Washington, D. C.

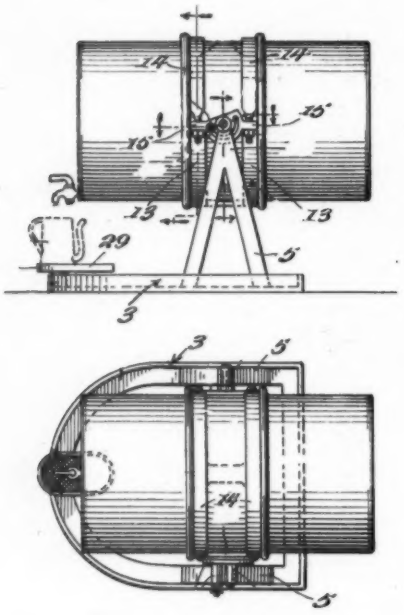


Fig. 4—Elevation and plan views of barrel stand with adjustable tray 29 mounted in base 3 (U.S. 2,419,786)

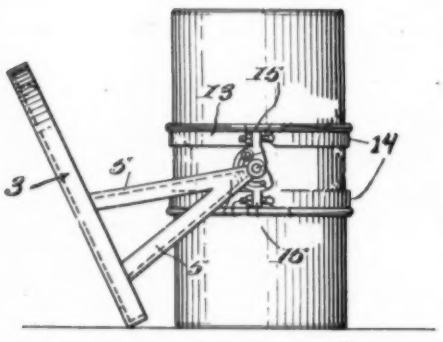


Fig. 5—Position of barrel stand shown in Fig. 5 after being secured to up-ended drum

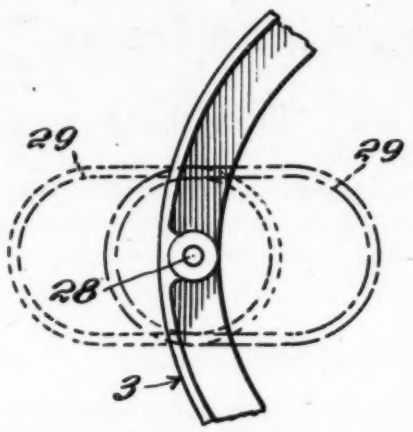


Fig. 6—Detail of adjustable tray mounting

Built-in Scraper Cuts Clogging In Gas-Jet Feed Injector

OBJECTIONABLE WHISTLING noises and the corresponding inefficient operation of gas-jet injectors for feeding granular material into a process gas stream are said to be eliminated in an improved feeder in which a scraper is installed inside the throat of the Venturi tube.

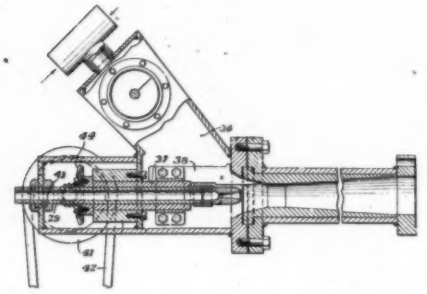


Fig. 7—Feeding device using scraper for removing clogged material from Venturi tube throat (U.S. 2,420,388)

As illustrated in Fig. 7 scraper blade 38 is mounted on hollow shaft 37 which fits around the gas jet pipe 29, and is driven by belt 42 and pulley 41 operating through gears 43 and 44. The forward section of blade 38 is shaped to fit the Venturi tube throat. The drive is adjusted for a rotation speed of the blade at about 8 to 10 rpm.

The action of the scraper not only clears up clogged conditions in the throat but stirs up solid material flowing through the feed box 16.

While designed primarily for pulverized coal because it makes possible handling coal with a moisture content as high as 10%, the device is equally adaptable to any similar operation. It is said to be particularly advantageous in cases where the solid material does have a slight moisture content.

U. S. 2,420,388, issued May 13, 1947, to William A. Thomas, assignor to Blaw-Knox Co.

Gas-Tight Downcomer Will Fit Variations in Column Diameter

GAS-TIGHT SEAL is provided in a bubble plate downcomer of new design. Means are supplied for adjusting the downcomer so as to compensate for slight variations which may occur in the internal diameter of the column in which it is to be installed, thus maintaining the desirable feature of a gas-tight seal.

A sectional view of the downcomer installed between two bubble plates is shown in Fig. 8, with an isometric view in Fig. 9. In operation, liquid flows over weir 19 on the upper plate and down through the space between downcomer 24 and wall 16 of the column. Then it flows under the lower edge of the downcomer, up over weir 18 into the lower bubble plate. This lower edge, being lower than the top of weir 18, furnishes the seal.

Adjustment to column diameters is illustrated in Fig. 9. Deflector plate 29 on the downcomer and deflector plate 29' on the weir have adjustable positions by means of slotted openings 31 and clamps 36.

U. S. 2,420,075, issued May 6, 1947, to Hans C. Glitsch, assignor, by mesne assignments, to Glitsch Engineering Co., Dallas, Texas.

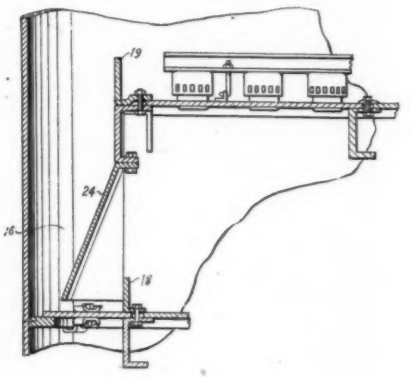


Fig. 8—Enlarged sectional view of improved downcomer which provides gas-tight seal between bubble plates (U. S. 2,420,075)

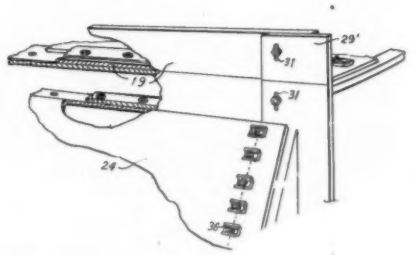


Fig. 9—Isome' means for

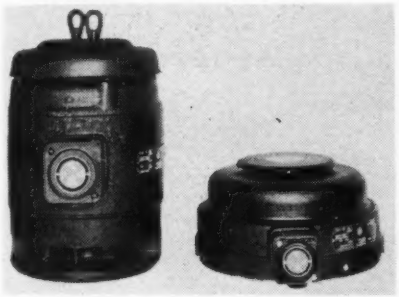
PF

What's New!

Edited by
William C. Uhl
Equipment Editor

EQUIPMENT . . . MATERIALS . . . PROCESSES . . . LITERATURE

1—Electric Motor



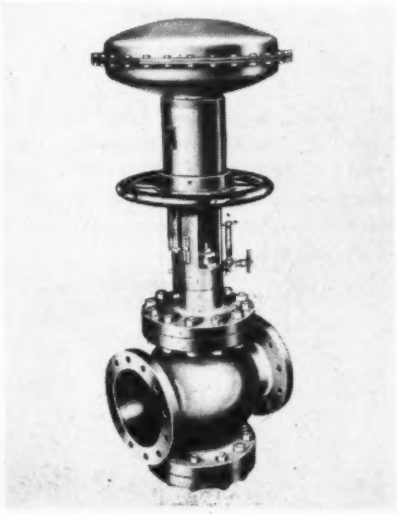
"Axial Air-Gap" is a new line of electric motors less than half the size of the conventional type motor and weighing about 30% less. Available in sizes ranging from 1/3 to 10 hp., it is suitable for horizontal or vertical flange mounting, or on an angle base for belt drive. The photograph shows frame size comparison for a 5 hp, 1800 rpm. model: the "Axial Air-Gap" is on the right, a conventional motor on the left. Design is based on the principle that the magnetic lines of force follow a path parallel to the shaft as compared to a radial path taken by the magnetic flux in the ordinary motor. Fairbanks, Morse & Co.

2—Clamp Supports

Applicable for use in electrical wiring because of insulating properties, a new line of clamp supports are made of a plastic material with high tensile and impact strength. Will withstand temperature changes ranging from −78° to +180° F., are unaffected by atmospheric conditions, and prevent corrosion and sweating. Available in 16 standard stock sizes from 1/8 to 1¼ in. diameter in 1/16 in. variations. The flexibility of the material permits the clamp to be slipped over wires, pipes, tubes, and the like. Holub Industries, Inc.

3—Handwheel Control Valve

Extra bypass piping and valves can be eliminated with the new Continuously Connected Handwheel Control Valve which incorporates an additional handwheel for emergency manual operation. Valve characteristics are the same whether on automatic or hand control. Travel limit stops can be set to limit the valve stroke from 0 to 100%. These stops can be set to permit a 25% valve travel. Should any failure of air occur, or the air line be broken, the control valve plug can only change its position plus or minus 12½%. A valve plug position indicator shows the settings in per cent free travel of the plug and shows whether the handwheel is in a neutral position. The handwheel can be applied to Hammel-Dahl valves from 2 to 12 in. Hammel-Dahl Co.



4—Portable Welder

The "Sureweld" portable gas engine-driven DC arc welder is furnished in two models: one mounted on a two-wheel dolly with pneumatic tires; the other a stationary type with a guard frame. Weighs 315 lbs., is 32 in. long, 26 in. wide, and 28 in. high, (without wheels). Fits into the back of a "Jeep" station wagon, the trunk compartment of some cars, and can be lifted by two men. The generator is a four-pole, self-excited type with interpoles. The welder is rated at 150 amps. at 30 volts on 50% duty cycle, and will handle electrodes up to and including 5/32 in. and certain types of 3/16 in. Powerplant is a two cylinder, four cycle, opposed design. National Cylinder Gas Co.

5—Safety Valve

A Nylon disc is said to be a satisfactory seating material for a new safety valve for air compressors. Working against a bronze seat, the nylon possesses all the essential properties of wear resistance, hardness, and flexibility. In addition, it is said to have a recovery characteristic which quickly seals off air leakage after the valve pops. The valve meets ASME requirements for air compressor service. Manning, Maxwell & Moore, Inc.

For More Information

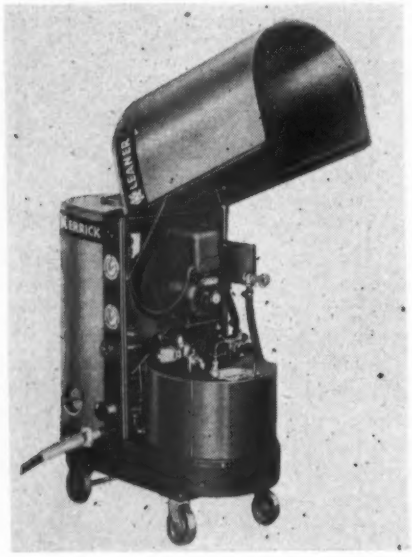
USE one of the attached business reply cards, which requires no postage, to request additional details or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail.

More "What's New" Items on Page 546

6—Slide Rule

The Deci-Log Slide rule is made of Dow metal insuring no warping or binding. It incorporates the following improvements: 1) Log log scales all refer to a single D scale and have a direct reading range from 10^{-10} to 10^{10}. 2) Powers (including those of base e) with both plus and minus exponents can be read with one setting of the hairline. 3) Exponential equations in which the unknown exponent is a negative number can be solved without transferring readings from one scale to another. 4) Includes an extra tangent scale for angles from 45° to 84.3.° Burrell Technical Supply Co.

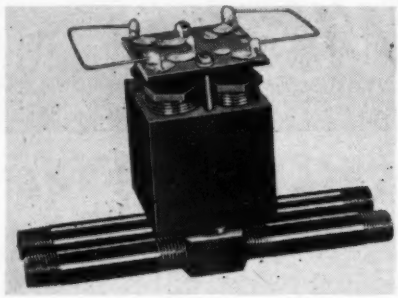
7—Steam Cleaner



New Model C "Kerrick Kleaner" is a steam cleaning machine said to include engineering features developed during the war to simplify cleaning under conditions encountered at combat transportation pools. All working parts are accessible for adjustment or cleaning by means of hinged hood. Accessory equipment in unit includes automatic soap injector, pressure atomizing burner, fully insulated fire box and shell, electrical ignition, protective fuel cut-off in case of water failure, and positive displacement pump requiring no lubrication. Clayton Manufacturing Co.

8—Gas Analyzer

Gas analysis is accomplished by means of the thermal conductivity method with the "Gow-Mac" unit, which can use standard laboratory instruments and accessories in its operation. The unit incorporates four filaments assembled in



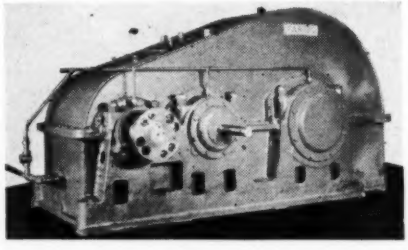
appropriate chambers and wired in a balanced bridge arrangement. Each element conforms to a predetermined standard of resistance. May be used with indicating, recording, or control instruments. Typical applications include special atmospheres, gas synthesis, inert gas generation and distribution. Size is 1½ x 3½ x 2-3/8 in. Each cell is tested to 10 psi. Gow-Mac Instrument Co.

9—Water Softener

The "Liquon" Hot Lime-Soda Softener has a deep sludge bed or blanket through which the raw water percolates upwardly, providing greater completeness of chemical reaction, and is said to use less chemical than conventional settling tanks. In addition, the sludge bed acts as a contact filter, effecting less load on the filters following the softener and reducing the frequency of backwash needed. Five types are available, providing a selection for different make-up requirements up to 100%, and for deaeration of make-up or of both make-up and condensate either separately or together. Each type includes provisions for chemical feed, vent condenser, filters with back-washing water recovery, and an automatic desludging valve for control of sludge bed depth. Liquid Conditioning Corp.

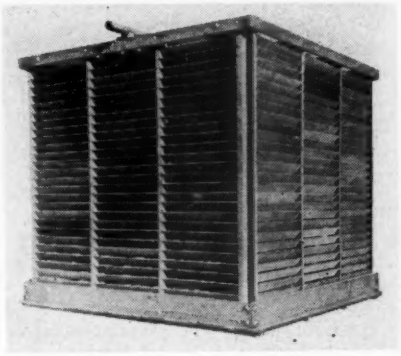
10—Speed Increaser

Ratios ranging from 12:1 to 40:1 are possible with a new line of double step-up speed increasing units. The unit shown is designed to transmit 1300 hp from a 240 rpm engine to a pump operating at 3150 rpm. Oversized shafts, ground to close tolerances and mounted



in precision sleeve bearings for the high-speed shaft and in anti-friction bearings for the intermediate and low-speed shafts, provide the necessary rigidity to guard against torsional deflections under peak torque variations. The intermediate shaft has an extension to drive auxiliary equipment such as a water pump or generator. Lubrication is by a self-contained circulating oil system. Farrel-Birmingham Co., Inc.

11—Cooling Tower

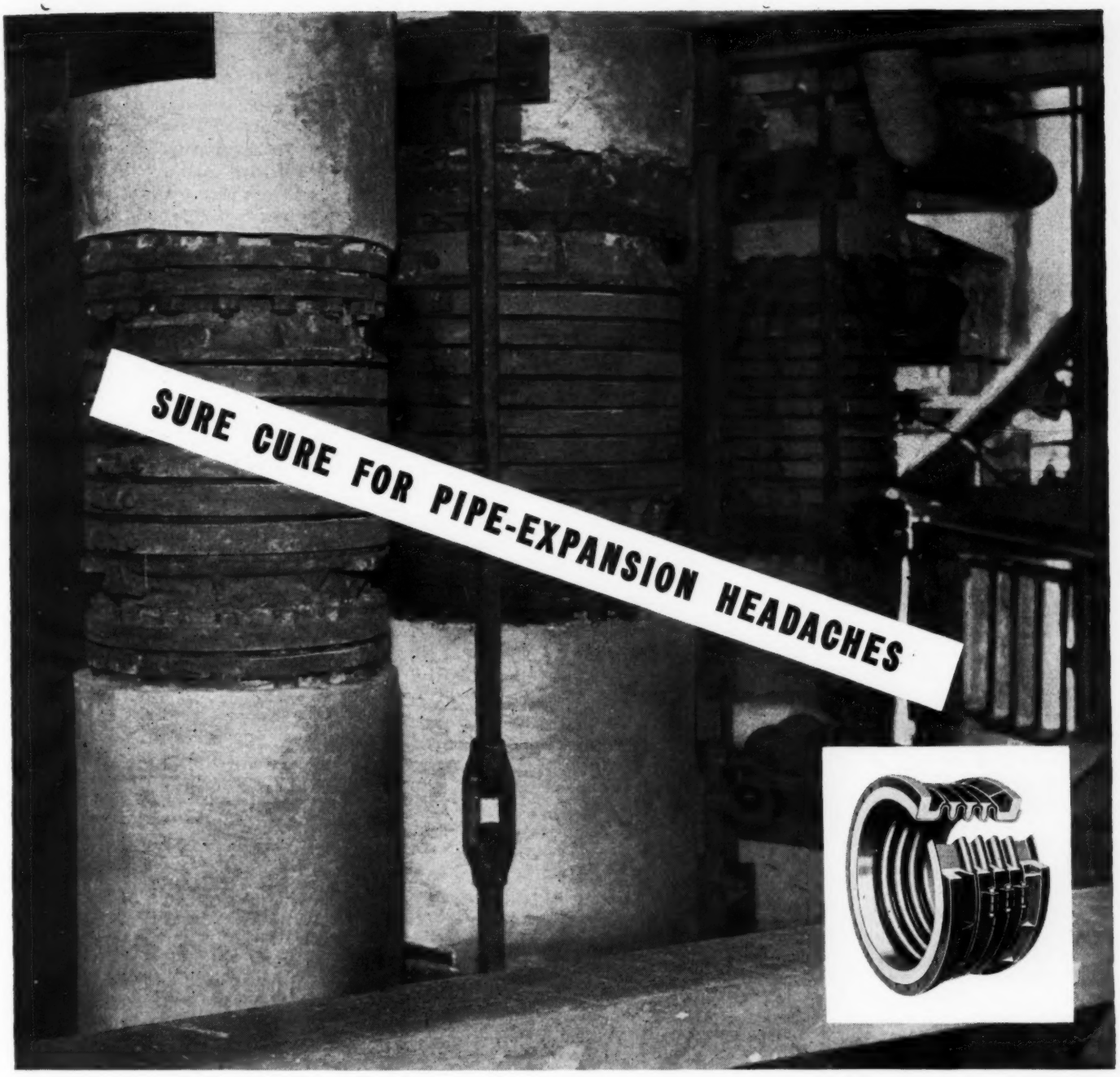


Prefabricated and shipped "knocked down" with each piece marked, and with erection, operation and maintenance instructions furnished, the Series 200 spray type natural draft cooling tower units are said to be adaptable for various jobs in a refinery where flexibility is a requisite. It may be purchased in various sizes, and can be used for open or closed cooling systems. It is designed in standard bays enabling an increase in tower size as requirements increase. Will withstand 100 mph wind in standard design. Earthquake design or 112 mph design obtainable at small additional cost. Capacity, 65 to 1580 gpm of water. Marley Co., Inc.

12—Boiler Scale Remover

The "NoKeM" process for correction of scale, pitting, corrosion, priming, and carry-over in boilers, preheaters, and split condensers operates by collecting and grounding out the existing electrical energy in the water. It is not a galvanic cell or cathodic type treatment. Once installed, no other treatment or replacement of parts is necessary it is said. It is put out as a service and leased to the user. It may be employed in any size boiler and is especially adaptable to high pressure service. NoKeM Engineering Co., Inc.

More "What's New" Items on Page 548



• *E. B. Badger & Sons Co. is the original and sole manufacturer of* **BADGER** *Expansion Joints*

BACKED by fifty years of experience, Badger has developed an improved Expansion Joint to meet the heavy and exacting requirements of the petroleum industry.

One important advantage of the Badger Packless Corrugated Expansion Joint is that its flexing member is formed from a SINGLE TUBE, hence requires NO PACKING. This eliminates costly and troublesome maintenance.

Furthermore, its simplicity and compactness insure EASY INSTALLATION and the use of MINIMUM SPACE.

Badger Packless Corrugated Expansion Joints are made of stainless steel and other alloys to withstand the high temperatures and corrosion constantly encountered in oil refineries and other petroleum processing plants.

A special heat treatment, after forming, further assures their corrosion-resisting qualities and thereby lengthens their serviceable life.

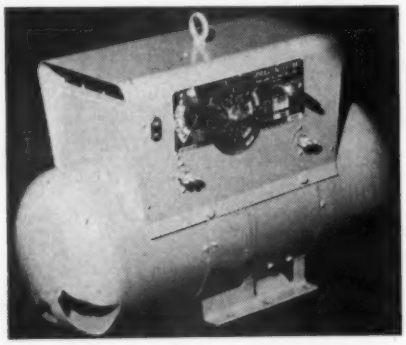
For further information about these dependable, long-lasting Expansion Joints and their application, send for Bulletin No. 100.

Badger

E. B. BADGER & SONS CO., 75 Pitts Street, Boston 14, Mass.
AGENTS IN PRINCIPAL CITIES

PACKLESS CORRUGATED EXPANSION JOINTS

13—D-C Arc Welder



Type WD-40, a line of high-speed DC arc welding machines, is said to save 50% in size, weight, and improved welding characteristics. Operating at 3500 rpm, it is available in 200, 300, and 400 amp. models. Full arc voltage is generated instantly after short circuit, avoiding unexpected pop-out of the arc. A single-dial, dual-range control makes it possible to preset the correct current without making other adjustments after the arc is struck. Weather-resistant end covers on both welder and control box can be removed with screwdriver. Standard assembly includes generator, drive motor, control cabinet and panel, and motor starter. Two wheeled running gear optional. General Electric Co.

14—Analytical Balance

Equipped with a direct reading device, the Voland analytical balance with "Visi Gram" records weights from 0.1 to 0.0001 grams on a counter with constant accuracy. Parallax and other visual distortion leading to errors due to misreading of a vernier are said to be eliminated. Operation is similar to that of the conventional vernier type chain balance. The weight is read in ordinary numerals appearing on a counter in the upper right hand side of the balance cabinet. Emil Greiner Co.

15—Apron Recoating

A recoating process using Neoprene latex applies the "retread" idea to laboratory and industrial aprons. A treated apron may be expected to last longer than the original garment it is said because it has been patched and reinforced at damaged area where it receives the greatest wear. The process can be applied to white or colored aprons as well as to the standard black types. "Retreaded" aprons are oil-proof, washable and pliable. Columbus Glove Manufacturing Co.

Trade Literature

16—Refinery Burners

Type MU Oil Refinery Burners, Bulletin No. 703, a new booklet containing diagrams showing the operation of the Peabody Type M and Type T steam atomizing burner with removable gas ring. Also has illustrations of the Type MU combined gas and oil burner, showing how the gas ring can be lifted out. Peabody Engineering Corp.

17—Vee Belts

Veelos, the Link V-Belt, a new 24-page catalog describing features of the adjustable type V-belt, construction details, instructions how to couple and uncouple, measure, and install. Also includes engineering data and photographs illustrating special and normal applications. Manheim Manufacturing & Belting Co.

18—Centrifugal Pumps

BJ Type TLB Bulk Station Pump, Bulletin No. 46-7000, a four-page leaflet of descriptive data on the "TLB" Pump, a centrifugal type designed to handle gasoline, butane, diesel fuels, lube oils and other hydrocarbons for bulk station service. Standard units have a capacity range to 600 gpm, discharge pressure to 150 psi, temperature to 150° F. Byron Jackson Co., Pump Division.

19—Strainers

Self-Cleaning Strainers for Steam, Air, Gas or Liquid Service, Bulletin 465, gives in eight pages a number of typical strainer applications for protection of regulators, regulating valves, stop valves, traps and process equipment. Includes tables showing screen specifications and total free hole areas to facilitate the selection of the correct screen for specific services. Also a chart plotting saturated and superheated steam flows and showing pressure drops for various pressures and temperatures. Leslie Co.

20—Stainless Weld Fittings

"Zephyrweld" Stainless Steel Welding Fittings, Catalog 747, offers data on physical characteristics, fabrication, and adaptability of welding fittings to other fitting types; stainless steel analysis tables; bursting pressure data; and information covering methods for installation with light gage commercial tolerance (O. D.) stainless steel tubing for lightweight corrosion-resistant liquid conveying lines. Tri-Clover Machine Co.

21—Instrument Chart

Basic Characteristics of Useful Industrial Laboratory Instruments, No. R-1066, is a two-page wall chart giving the following information: Seven vertical columns have the headings; name of apparatus, operating principle, basic arrangement, operation, applications, comments, and name of manufacturers or suppliers. A total of 15 instruments are covered in the tabulation including the electron microscope, geiger counter X-ray spectrometer, mass spectrometer, X-ray and electron diffraction devices, and others. North American Philips Co., Inc.

22—Turbines

Mechanical Drive Turbines, Bulletin H-16, describes the new Elliott YR line of turbines, containing complete general and material specifications, including approximate dimensions for each type frame available in the YR line. Elliott Co.

23—Stainless Valves and Fittings

Aloyco Catalog No. 47, contains 54 pages covering all standard Aloyco corrosion resistant valves and fittings, including photographs and cross-sections, dimensional data, and list of alloys in which each style is stocked. Alloy Steel Products Co.

24—Processes and Plants

Lummus Petroleum Processes and Plants, Bulletin R-10, is a 64-page booklet illustrated with photographs, flow diagrams and descriptions of most of the major refining processes now in use in the petroleum and petroleum chemical industry. The Lummus Co.

25—Wrenches and Pliers

Bulletin No. 4728, describes and illustrates the complete line of pliers, adjustable wrenches, and pipe wrenches now offered by the Plomb Tool Co.

For Your Convenience

Business reply cards are included in this issue of PETROLEUM PROCESSING to assist you in obtaining more information on any of the items reviewed in "What's New!" You'll find them facing page 545. Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail. No postage required.

MEETING

Refineries Must Have Catalytic Cracking To Meet Competition, Frame Tells API

12th Mid-Year Meeting of Refining Division Hears What Quality of Future Motor Gasolines Will Be, Requirements For Jet Engine Fuels, Among Other Technical Papers

A STAFF REPORT
by the Editors of
Petroleum Processing

TOMORROW'S refinery must have catalytic cracking if it is to produce competitive quality gasoline, A. P. Frame, vice president of Petroleum Advisers, Inc., New York, (Cities Service) told the 12th mid-year meeting of the American Petroleum Institute's Division of Refining, held in St. Louis June 2 and 3.

Speaking on "A Refiner's Look at Gasoline Quality," Mr. Frame gave his opinion of what gasoline quality would be in 1950, compared with the last prewar year—1938, and how that quality would be obtained.

"Catalytic cracking," he stated, "is not a refinement of thermal cracking; from the standpoint of producing gasoline quality it is as far ahead of thermal cracking as thermal cracking is ahead of simple distillation. Few refineries could exist in 1938 without thermal cracking facilities, and, in my opinion, few refineries making average quality gasoline will be able to exist in 1950 and beyond without catalytic cracking facilities."

Octane rating of motor gasolines in 1950, Mr. Frame estimated, will have increased from 72 to 79 (ASTM) and from 77 to 85 (Research) for regular grades, and from 79 to 84 and from 84 to 94, respectively, for premium brands.

At the same time, the boiling range of gasolines will be appreciably higher than prewar, and the chemical composition will be higher in aromatic and olefinic compounds and lower in paraffinic and naphthenic constituents.

Small Refiner's Problem Intensified

This expected increase in gasoline quality and the need for some method of meeting competition, Mr. Frame believes, is bound to intensify the already serious problems of the little refinery—whether owned by a large or small oil company.

"Catalytic cracking units," he went on to explain, "are costly to build and expensive to operate, and, as is almost invariably the case, the more costly the process the greater the penalty of building and operating small-capacity units.

"As illustration, the capital investment today for a catalytic cracking unit of a size to produce 7000 bbls. of gasoline per day is about $800 per daily barrel of gasoline production, nearly three times the cost of thermal cracking unit of the same gasoline production capacity. For a smaller catalytic cracking unit of a size to produce 1500 bbls. of gasoline per day the capital investment is about $1200 per daily barrel of gasoline production. For even smaller capacities in catalytic units the unit costs will, of course, be even greater.

"The improvement in the value of the yields due to catalytic cracking versus thermal cracking is just as real in the small units as in the larger ones but the penalty against the small catalytic units due to higher unit operating costs and particularly due to the higher unit capital charges is serious. For instance, the difference between the capital investment per daily barrel of gasoline production for the 7000 bbl. catalytic units versus the 1500 bbl. unit is perhaps $400 per daily barrel of gasoline production.

"If the capital charges, including maintenance expense as well as depreciation and interest, amount to 20% per year the production cost of the gasoline from the small unit will be over one-half cent per gallon higher than from the larger unit, due to the higher unit capital cost of the smaller unit.

"This points up one of the generally unpalatable facts of economic development, to wit, that as process industries become more complex requiring more capital investment per unit volume of production, the free play of economic forces tends to concentrate such processing industries into larger and larger units.

"I am very sure that many of the small refineries in this country today will weather the storm created by the general adoption of catalytic cracking and the attendant increase in gasoline quality by installing catalytic units of their own or in conjunction with others. Some by virtue of geography or a preferential crude suply or by concentrating on the manufacture of products other than gasoline or even through the production of a lower than average quality gasoline will successfully meet this challenge, but on the other hand many, perhaps too many, of the present small refineries will not be able to survive the gasoline quality competition that almost surely lies ahead and we may expect an acceleration in the rate of decline in the number of operating refineries in this country."

Based on Typical 1938 Refinery

In making his predictions of what gasoline quality will be in 1950, Mr. Frame "synthesized" a typical modern refinery of the year 1938.

"This typical refinery," he explained, "I have set up as having a balanced crude capacity of 75,000 b/d of an average Mid-Continent crude. The process facilities in this 1938 refinery would consist of crude topping units, capable of cutting 300° end point straight run gasoline; a reforming naphtha cut from 300 to 400°; a kerosine stream; a straight run distillate fuel oil stream, and a light and heavy gas oil side stream for thermal cracking unit charge. The bottoms of the crude units would go to a vis breaker under recycling conditions for the production of heavy fuel oil and additional cracker charging stock. The thermal cracking equipment would consist of a thermal reforming unit and gas oil thermal cracking units of a capacity to permit of recycling to extinction. There would also be a catalytic polymerization unit for the conversion of butylenes and propylenes to motor gasoline. This refinery would produce yields of products as shown in Table 1.

"The yields from this refinery have been set so that the kerosine yield and the yield of distillates (as 100% straight

run product) approximate the national average yields for 1938. The yields of other products have been calculated on the basis of the most efficient operation of the process facilities already described.

"In determining the quality of the gasoline from this 1938 refinery, it has been assumed that the premium grade gasoline production amounts to 10% of the total gasoline production, which is a higher percentage than the national average of slightly over 7% for the year 1938. It has furthermore been assumed that this refinery, being completely modern as of 1938, would be producing gasolines one octane number higher than the national average for this period so that the amount of lead tetraethyl shown in the inspections is that amount necessary to meet these specified octane numbers. With these assumptions the quality of gasolines from the 1938 refinery would be as shown in Table 2.

"On the basis that this hypothetical refinery was completely modern as of 1938 from a processing standpoint it has not been assumed that this refinery would then have been producing gasoline quality up to the absolute limit of its ability as evidenced by the fact that the lead content as shown on the inspections is relatively low. Those refineries in 1938 which were not so well equipped with modern processing facilities would, and did, require the use of greater quantities of lead tetraethyl to meet competitive gasoline quality. Nevertheless I believe it to be true that the 1938 quality of gasoline was fundamentally set by refineries having process facilities similar to those described for our hypothetical plant.

"If it is possible for us to estimate what probably would have happened to this typical 1938 refinery because of the war and the postwar situation it should be possible to forecast what quality gasoline this refinery will be making in 1950 and if our forecast includes what actually has happened and will happen to a sufficient number of existing refineries we should be able to calculate the quality of gasoline that will be produced in 1950, always assuming that the necessary assumptions prove to be correct."

War Will Influence Future Operations

Mr. Frame then detailed three war-caused factors which he believes will influence future refinery operations:

1—Increased crude runs.
2—Addition of catalytic cracking.
3—Demand for premium gasoline.

In 1938, he pointed out, daily national average refinery crude runs were 3,192,000 b/d, which he estimated would rise to approximately 5,000,000 b/d in 1950. On that basis he assumed that a refinery running 75,000 b/d in 1938 would increase its run to 100,000 b/d in 1950.

Catalytic cracking units built during the war, according to Mr. Frame's figures, had a total virgin gas oil charging capacity of 750,000 b/d, and an additional 250,000 b/d capacity has been definitely projected since the war. By 1950, he estimates, there will be in operation catalytic cracking units with a total charging capacity of approximately 1,200,000 b/d, or sufficient to handle all the available straight run gas oil from about 60% of the expected 1950 crude run.

"For this reason it should be a safe assumption that our hypothetical refinery, being desirous of maintaining its relative 1938 position, will have sufficient catalytic cracking units in operation to handle all the available straight run feed stock on a once-through basis.

"Furthermore, our hypothetical refinery undoubtedly would have installed during the war alkylation capacity up to the limit of olefin availability, although it is probable that the 1950 operation of these faciliites will be at only a fraction of wartime capacity."

The third factor, premium gasoline demand, will have "a very real effect on the 1950 gasoline quality picture," Mr. Frame stated.

"Prior to the war any company which sold 10% of its total gasoline production in the form of premium gasoline was definitely higher than average. During the war, perhaps because of gasoline rationing and degradation of general gasoline quality, the consumers clamored for ever-increasing amounts of the premium grade gasoline. . . . Today, perhaps because of a carryover from the war induced situation, the demand for premium gasoline is about 40% of the total gasoline production."

An appreciable amount of today's high demand for premium grade fuel, in Mr. Frame's opinion, is caused by the fact that "people, in general, have money and that people, in general, assume that whatever costs more is necessarily better for their use."

"It is my own personal opinion," he continued, "that when the flush of wartime savings is dissipated and the general availability of consumer goods becomes greater the increased competition for the lesser number of consumers' dollars will result in a definite decrease in the demand for premium grade gasoline.

"For this reason I have assumed that the amount of premium gasoline production from our hypothetical refinery in 1950 will be 25% of its total gasoline production, midway between the 1938 percentage and that existing today."

What the 1950 Refinery Will Do

Based on the three factors outlined above, Mr. Frame then projected his 1938 refinery into 1950, when it would be handling an estimated 100,000 b/d. "I have assumed this refinery to have process facilities consisting of crude topping units, capable of cutting 300° end point straight run gasoline; a reforming naphtha cut from 300 to 400°; a kerosine stream; straight run Diesel fuel stream, and a gas oil side stream for catalytic cracking unit charge. I have assumed that the bottoms of the crude units would go to a vis breaker operating on a once-through basis for the production of heavy fuel oil and additional cat cracker charge, the catalytic cracking units to have sufficient capacity to charge

TABLE 1—1938 Refinery Yields

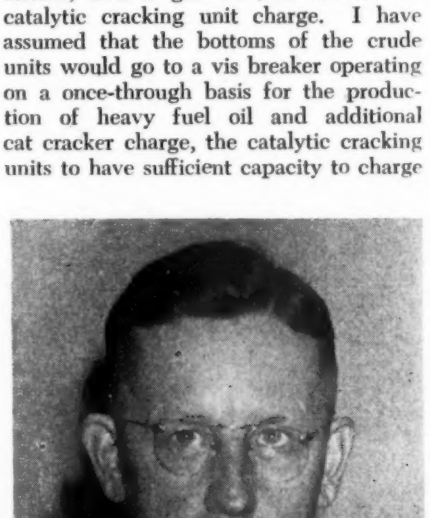
Product	% Yielded
Gasoline*	53.8
Kerosine	5.5
Distillates	13.0
Residual Fuel Oil	23.5
Gas and Loss	4.2
Total	100.0

* 68.3 ASTM octane No., clear.

TABLE 2—1938 Refinery Gasoline Quality

	Regular Grade	Premium Grade
10% Evaporated, °F.	125	125
50% Evaporated, °F.	212	195
90% Evaporated, °F.	340	300
End Point	400	400
Vapor Pressure (psi)*	10	10
Octane Number—ASTM	72	79
Octane Number—Research	77	84
TEL (cc's per gallon)	0.3	1.0
Hydrocarbon Analysis		
% Paraffinic	55.0	53.0
% Naphthenic	13.0	6.0
% Aromatic	16.0	9.0
% Olefinic	16.0	32.0

* Regular grade gasoline requires 2.3% of extraneous butane to meet vapor pressure.



During the war, A. P. Frame, who spoke at the recent API Refining Division meeting on future gasoline quality, served as Director of PAW's Refining Division. Prior to that he was vice president and chief engineer of Cities Service Refining Corp., and today is vice president of Petroleum Advisers, Inc., New York, Cities Service subsidiary

TABLE 3—1950 Refinery Yields

Product	% Yielded
Gasoline*	58.3
Kerosine	5.5
Diesel Fuel	3.5
Distillate Fuel	16.0
Residual Fuel	10.9
Gas and Loss	5.8
Total	100.0

* 72.9 ASTM octane No., clear.

TABLE 4—1950 Refinery Gasoline Quality

	Regular Grade	Premium Grade
10% Evaporated, °F.	125	125
50% Evaporated, °F.	210	200
90% Evaporated, °F.	350	325
End Point	425	400
Vapor Pressure (psi)*	10	10
Octane Number—ASTM	79	84
Octane Number—Research	85	94
TEL (cc's per gallon)	1.1	1.0
Hydrocarbon Analysis		
% Paraffinic	45.0	32.0
% Naphthenic	12.0	2.0
% Aromatic	23.0	16.0
% Olefinic	20.0	50.0

* Regular grade gasoline requires 1.9% of extraneous butane to meet vapor pressure.

all the straight run gas oil with the exception of the Diesel fuel stream. The thermal cracking capacity would consist of a thermal reforming unit and capacity for cracking that portion of the catalytic cycle stock not suitable for heating oil.

"It is also assumed that the catalytic polymerization unit would be operated to the same capacity as in 1938, producing propylene and butylene polymer, and that the alkylation facilities, installed during the war, would be operated to balance the vapor pressure of the gasoline, assuming that the same total volume of extraneous butanes as used in 1938 would be available to the refinery. On such a basis the product yields would be as shown in Table 3.

"When these 1950 yields are compared with the 1938 yields as shown in Table 1 it is interesting to note that the 1950 percentage yields of gasoline and distillate fuels, excluding kerosine, have increased by 8% and 50%, respectively; that the kerosine percentage yield is unchanged and that the percentage yield of residual fuel has decreased by 54%. If the yield comparison is made on the total volume production our 1950 hypothetical refinery would produce in barrels 44% more gasoline, 33% more kerosine, 100% more distillate fuels and 38% less residual fuel. It will be of more than passing interest, I am sure, that the 1950 percentage yields represent an increase of about $.11 per barrel of crude in the total value of refined products yielded than do the 1938 yields based on today's price structure."

Quality of Other Products

. . . "future gasoline quality cannot be calculated, from a refinery standpoint, without making certain assumptions as to the future quality of other products, primarily distillate fuel oils. In our calculations as to the yields and qualities of our 1950 refinery it has been assumed that the production of Diesel fuel oil would be a 100% straight run product and that the yield of domestic heating oils would be 100% catalytically cracked material with the exception of the addition of sufficient straight run naphtha to meet the front end boiling range specifications.

"This method of refining operation appears to me to be a necessity if both expected gasoline quality and volume of heating oil distillates are to be obtained. I recognize that such quality of heating oil distillates will probably cause consumer difficulties if such a distillate is used in poorly designed or the wrong type of domestic oil burner but I nevertheless firmly believe that this catalytically cracked material is what the refining industry is going to produce almost exclusively in the near future. . . .

"Returning to our course, Table 4 lists the inspections of the gasoline quality as produced in our 1950 refinery.

"Comparing these data with the inspections for the 1938 Refinery, shown in Table 2, it can be seen that the outstanding differences are that the boiling range of the 1950 gasoline is appreciably higher than in 1938; that the ASTM octane number of the regular gasoline has increased from 72 to 79 while the Research octane number has increased from 77 to 85. We have estimated that for the premium grade gasoline the ASTM octane number will have increased from 79 to 84 while the Research octane number will have increased from 84 to 94. The change in the chemical composition for the 1950 gasoline in general is a pronounced increase in the percentage of aromatic and olefinic compounds with a corresponding decrease in the percentage of paraffinic and naphthenic constituents.

"The reason we have estimated that there will be an increase in the boiling range of the 1950 gasoline is because of the inherent characteristics of catalytic cracking units to produce high octane number quality in the heavy gasoline boiling range. For instance, a catalytically cracked naphtha boiling between 400° F. and 450° F. will have an ASTM octane number of 78 and a Research octane number of 89. This high quality in a catalytically cracked naphtha coupled with the expected high demand for gasoline will, I believe, provide an almost irresistible pressure on refineries to include this relatively heavy material into their gasoline production. This situation is already becoming evident in certain sections of the country which are currently being supplied by refineries having an appreciable amount of catalytic cracking capacity.

"As has already been pointed out, the projected gasoline quality for the 1950 refinery has been predicated on the production of 25% of the total gasoline as the premium grade. If, in 1950, the percentage of premium gasoline demand should be as low as the 1938 figure, namely 10%, the octane numbers of the housebrand gasoline then would be 79.5 ASTM and 86.5 Research and the premium gasoline 85 ASTM and 95.5 Research. If, on the other hand, the demand for premium gasoline should continue into 1950 at its present percentage of 40% of the total gasoline demand it is estimated that the octane numbers of the housebrand gasoline would in that case be 78 ASTM and 83.5 Research with premium gasoline 83 ASTM and 93 Research."

"Is the Octane Race Worth While?"

In a later section of his paper, Mr. Frame propounded what he termed the "$64-question"—Is the octane race worth while?

"Worth while to whom?" he continued. "To the owner and operator of a small refinery faced with the problem of installing increasingly expensive process facilities and competing with the inherently less costly production from larger units or attempting to market his gasoline of less than competitive quality at less than competitive prices; his original economic advantages of transportation savings and flexibility of operations being slowly but surely whittled down by the hard cold facts of economic and technological developments? To this refinery, be it owned by a large or small oil company, the octane race has been and will be a struggle for existence and most assuredly its answer to the $64 question would be a resounding 'No'.

"Is it worth while to the owner and operator of a large refinery when competitive gasoline quality forces him to pyramid millions of dollars on millions of dollars to his capital investment and to relegate to the scrap heap refinery processes which still could have years of serviceable life? True, many of the new processes enhance the yield value of a barrel of crude oil and with steadily increasing volume of business he can justify economically the huge expenditures required, but many a thoughtful refinery manager has looked back at the record of increasing gasoline quality and decreasing gasoline price and has wondered if such a rat race really is worth while. I think the most truthful answer that could be given to our question by such a man would be a noncommital 'Maybe'.

"Is the octane race worth while to the engineering firms and equipment suppliers which service the refining industry? The answer to this question is so apparent it scarcely needs a reply since the octane race has provided the bread and butter, yes and cake too, for such outfits for years. I'm sure we can safely say their answer would be a unanimous 'Yes'.

"Is it worth while to the automotive industry? This industry has, for years,

been able to design and produce new cars having better efficiency or performance charcteristics than those produced the year before. A major reason for this development has been that the petroleum industry has consistently produced and made readily available a higher quality gasoline than the currently produced cars required. This consistent improvement in the performance of the new model cars certainly played no small part in increasing the demand for the new cars. Certainly the availability of better fuels was not the only factor aiding in the design of new cars which stimulated the demand; there were many other factors both engineering and sartorial but I feel sure that the automotive industry would agree that the consistent improvement in gasoline quality has in the past and will again in the future aid them in the marketing of increasing numbers of new and better automobiles and trucks. Therefore I believe that this industry would return a unanimously affirmative answer to our question.

"Is the octane race worth while to the petroleum industry as a whole? The greatest single factor contributing to the acknowledged virility of the petroleum industry is that it has been and still is a rapidly expanding industry. The growth of our industry goes hand in glove with the growth of the automotive industry whose products consume directly about 50% of our entire production and indirectly create a demand for a great deal more. Our contribution to the growth of the automotive industry by producing and marketing better and better fuels, thus encouraging the design and production of more and better automotive vehicles, is returned to us many fold in ever increasing demand for our products. There have been and there will be economic casualties, particularly in the refining branch of our industry, along the road of ever increasing gasoline quality, but the petroleum industry as a whole has profited and profited well by continually building better and better fuels for internal combustion engines.

Public Holds Final Verdict

"Finally let us present the $64-question to the jury whose verdict is final. Is the octane race worth while to the people of this country? Although the people are the final jury to decide this question they are not unbiased because it is they who aid and abet the octane race itself. Influenced by advertising claims perhaps they tend to place their business with the oil companies having the highest quality gasoline. It is true that often they buy gasoline too high in quality to be completely appreciated by their present car but through their buying preference they set in motion a whole train of circumstances leading to ultimately more efficient cars for themselves and a higher level of industrial production for all. It seems to me that the so-called octane race which historically has consisted of the petroleum industry selling greater and greater quantities of higher and higher quality gasoline at prices which have been well below the price level of other commodities, and which has contributed to the expansion of the automotive industry and consequently all industry, should be regarded as an outstanding example of the advantages of free enterprise in a democratic state. Looking at the broad picture it appears impossible to believe otherwise but that the octane race, heartbreaking as it seems at times, is worth while for our industry and the country as a whole."

Availability of Fuel Being Considered In Design of Jet Aircraft Engines

AVIATION gas turbine engine designers today are giving considerable thought to the type of fuel which their engines will require, according to A. J. Nerad, General Electric Co., Schenectady, N. Y., rather than first designing an engine and then asking the petroleum industry to supply the optimum fuel for it.

Speaking on "Fuels for Jet and Propeller Gas Turbine Engines," Mr. Nerad told the 12th mid-year meeting of the API Refining Division that the most important factor in determining the choice of a fuel for the propeller and jet turbines is probably the quantity or rate at which such fuel will be required.

"Considering that the demand for this fuel will be large in the future," he said, "we can only point our choice of liquid hydrocarbon fuels to what is or will be highly available. As the automotive engine has a history of over 60 years with one fuel, gasoline, and evolved together with it to its present high degree of performance and reliability, so it is desired that a fuel is chosen for the aviation gas turbine with the same possibilities of supply and development."

Although he presented no definite specifications for such a fuel, he did state that the fuel considered most readily available has the low end volatility of gasoline, is high in aromatics, and has high sulfur tolerance, low viscosity, and a gum content limited only by the plugging of the fuel system.

In making a fuel choice, Mr. Nerad pointed out, "the full possibilities should be considered that the combustion and fuel system can be adjusted to fit such an available fuel. The possibilities of the adjustments of the fuel type to give the best margins to the engine within the limits of availability should also be considered.

"In these respects the very extensive work already done by all agencies interested in the problem to determine the effect of fuel types on engine performance has shown some points of agreement, and some points of conflict, between the ideal engine fuel and ideal available fuel." Mr. Nerad then went on to detail some of these points, as follows:

Effect on Combustion Efficiency

In order to obtain maximum efficiency from a fuel of higher volatility than that for which combustors are now designed, some changes in the tore strength (see Fig. 1) are needed.

In general, the more volatile fuel allows for higher efficiencies at the very low pressures, since the ready vaporizing of the fuel compensates for lack of fineness of atomization at low pressures. With less volatile fuels, low fuel flow and poor atomization are obtained under starting conditions. It has been noted that in starting engines with gasoline, a much cooler exhaust temperature is obtained than in starting with kerosine.

Again, the same result of cooler starts has been obtained with special fuel nozzles which give finer atomization. There are components in fuels which have in-

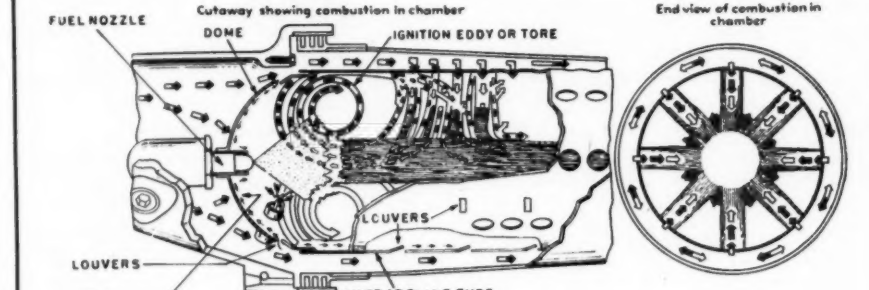


Fig. 1—Cutaway diagram of combustion chamber of an aircraft gas turbine engine, showing mixing and combustion of fuel and air

dicated effects on combustion efficiency other than from changes in volatility. It is likely that these are slower burning components which require finer atomization. The thorough testing of a fuel would reveal this and it would have to be decided if combustion system or fuel need be improved.

Carbon Formation, Flame Tube Life

A fuel as proposed offers two opposite effects over the present fuel. The aromatic component of a fuel is considered a ready source of carbon formation and smoke. Carbon deposits have a deleterious effect on flame tube life. The fuels with high volatility, however, tend to form less carbon. It has been shown, however, that carbon formation may be eliminated through the use of an air film on the inside of the flame tube, as shown in Fig. 1. The degree of freedom from carbon deposits depends entirely on the perfection of this film. It is a difficult problem to establish a perfect air film or film of low fuel/air ratio, for it requires, among other things, very uniform air flow. However, this is the indicated method by which fuels of high aromatic content may be successfully burned in combustors.

Initial Ignition

In starting an engine in cold weather or in starting or restarting an engine at high altitude, a volatile fuel is advantageous. It is necessary to obtain a combustible mixture at the spark in order to propagate a flame. In the interest of safety, a fuel most readily ignited under these conditions must be the choice, and with a given atomizing system the volatile fuel is the one. For starting under all conditions, including hot weather, some modification in the ignition zone is necessary to avoid over-rich mixtures under sea level starting conditions.

Controls and Fuel System

A change of fuel to the volatile type of low viscosity undoubtedly introduces serious problems in the fuel system, particularly in the pumping. In this respect, there is work involved in converting from a fuel of the kerosine type. There are those who feel with considerable justification that emergencies in all types of aviation will require that the engines operate properly on gasoline. If this is a requirement then the problem is one of degree alone and does not afford an insurmountable obstacle.

Economics and Safety

The use of kerosine as a fuel for aviation gas turbines has been mentioned in various publications as an inexpensive and safe fuel. Cost and availability are linked together, and in the event of a great demand for a special type of kerosine the economics bear restudy. The consideration of the relative safety of a fuel requires a thorough study under all conditions of manufacture, handling, storage and use. This has been and is being studied, but there is yet not enough support for the relative merits of the low volatile fuel. There are conditions under which kerosine is unsafe when a high volatility fuel is safe, and vice versa.

Possible Changes in Future Engines

As the choice of a fuel may be affected by the particular conditions encountered in an engine, a survey of these conditions for proposed new designs is desirable. One may guess, however, that the principal changes will involve higher pressures in the combustion chambers, higher temperatures to the turbine nozzles and a greater range of pressures when higher altitudes are obtained. Such changes (except the last) do not greatly influence the choice of fuels. A volatile fuel is beneficial under such conditions.

Atomization

It has already been mentioned under combustion efficiency that a more volatile fuel is advantageous when atomization is deficient. In ordinary vortex nozzles of the Monarch type, a minimum fuel flow is required for proper atomization and this is above the necessary minimum to cope with engine conditions and fuel pump limitations. Besides this, a fuel of low viscosity is readily atomized. The need for proper injection without too great or too little penetration must be recognized. A change of fuels usually requires a restudy of the fuel injection system.

In the various seven items above it is indicated that minor changes in combustor and more serious changes in the fuel system are required to fit in with this available fuel. Should it develop that the engines find this fuel as satisfactory as or superior to the kerosine types, its general adoption might start us off on a 60 year history of the evolution of an engine and fuel combination as successful as the automotive engine.

Practical Aspects of Other Papers Presented at API Refining Meeting

A NUMBER of valuable papers of practical importance to refiners marked the 12th mid-year meeting of API's Division of Refining. Several are not in a form where they may be immediately useful, in that they are as yet highly technical research reports describing fundamental investigations, but most will be readily translated directly or indirectly into terms of plant applications.

N.G.A.A. Committee Reports On Vapor Lock Tolerance Tests

A research paper of immediate application in refinery practice presented during the meeting was entitled "The Nowata Road Tests and Their Economic Significance," a report by the Technical Committee of Natural Gasoline Assn. of America delivered by K. C. Bottenberg, Phillips Petroleum Co., Bartlesville.

This paper relates the results of tests undertaken by N.G.A.A. to determine the vapor lock tolerance of 16 late model automobiles in the temperature range of 30 to 75° F., and more particularly 30 to 55° F., the winter range for the northern area of the U. S. Two base fuels were used, one (high volatile) having more than 70% evaporated at 212° F. and the other (low volatile) slightly more than 40%. Portions of both were pressurized with *n*-butane to a 26-lb. Reid vapor pressure and blends of the two corresponding fuels made to attain the desired intermediate vapor pressures.

The cars were so operated on the road that conditions would be such during each test to favor vapor lock if it were going to occur; i.e., engine warmed up by a 20-30 mile run at 50 mph, soaked with ignition off for maximum fuel system temperature rise, and accelerated from 10 to 60 mph in high gear. Fuel was sampled from the tank immediately preceding and following incipient vapor lock for analysis.

Significantly, it was first found that two of the cars tested were unduly restrictive as to vapor lock, due to fuel system design and location of components; the manufacturers are taking steps to remedy this in future models. Secondly, it was determined that the maximum permissible vapor pressure for high and low pentane content fuels in the balance of the cars tested was 14.9 and 15.1 psi, respectively, at 55° F.; 20.6 and 20.7 psi at 35° F.

Considering monthly gasoline consumption in those parts of the U. S. where the average daily maximum temperature does not exceed 55° F., raising the vapor pressure to 15-lbs. R.V.P. would permit using 9,000,000 bbls. of butane, automatically adding that volume to the total of gasoline otherwise available. If 50% of the volatility in terms of pentane content of the high volatile fuel were attained with, say, a 12-lb. natural gasoline, the potential volume of this material which could be utilized would approach 90,000,000 bbls.

Losses of product in storage due to the higher vapor pressures are discounted by this investigation, tests showing that increases in tank losses in the auto after 50 miles of driving at 50-60 mph were 0.26 and 0.46 vol.-%, respectively, for the pressurized high and low volatility fuels. Total losses of 1.88 and 1.54%, respectively, for the two fuels compares favor-

ably with the 1.53 vol.-% loss observed with 9-lb. R.V.P. gasoline at temperatures ranging from 79 to 98° F. in tests ten years ago. Manufacturers of dispensing equipment state there will be no difficulty with filling station equipment using 15 R.V.P. gasoline at temperatures 55° F. and below.

These figures give an interesting argument for refiners to save the butane content of their refinery gases for motor fuel blending, also indicate that gasoline output can be increased during winter months (or crude runs decreased correspondingly) by boosting vapor pressure to 15 lbs. An additional saving is reported possible by this committee's work in that the high blending octane value of butane also can be taken advantage of in permitting a corresponding reduction in amount of tetraethyl lead used for a given finished product octane number. They report increasing the *n*-butane content of motor fuel to boost vapor pressure 2 lbs. Reid is the equivalent of an increase of 1.5 O.N. at a level of 76 ASTM with 2 cc. lead per gal.

Laboratory and Field Stability Measurements Compared

"Correlation of Accelerated and Laboratory Storage Measurements of Gasoline Stability with Field Stability" by E. L. Walters, Shell Development Co., Emeryville, Cal., represents a creditable boil-down of the large amount of data accumulated over three years by the CRC-MFD Gasoline Additives project in desert storage tests on 80 octane all-purpose gasoline.

The practical application of this work lies in the fact it proves properly chosen laboratory accelerated stability and storage tests are capable of satisfactorily predicting what will happen in the field. Its further value is in the development of modified stability tests from which such predictions can be made with reasonable accuracy. Of particular interest is the representation of all major U. S. (as well as some foreign) crudes and a variety of refining methods in the products tested.

Limiting factors which should be borne in mind when considering these data are three: (1) Tests were carried out on a very special fuel, from which naturally-occurring stability promoters were removed as an incident to refining. (2) The periods and conditions of storage were unusually long and severe compared to peacetime practices. (3) Correlations are poorer with extended periods of storage (no known accelerated test affords a reliable measure of stability under these conditions), apparently because of the increasing importance of such unknown factors of container type, aeration and contamination.

It was brought out that, in particular, two accelerated laboratory tests are of greatest validity in predicting storage stability. These are the ASTM 480 minute induction period (now method D 525-46) with added restrictions and the 5-hour Aging Gum test (D 873-46T outlines the procedure) with fewer restrictions. The restrictions refer to the specification limitation of antioxidant type and concentration (maximum and minimum) and the 4 mg. initial ASTM gum requirement. It was found also that laboratory storage stability tests, in glass, correlate better with accelerated stability tests than do field tests.

The validity of any type of laboratory test depends greatly on proper assumption of storage conditions, particularly liquid temperature. Average air temperature is not a satisfactory figure to use, since it was found that average liquid temperature ranged from 0 to 20° F. above air temperature, depending on season and weather—rain, cloudy or clear—and color of the outside surface of the container.

Fuels tend to form gum more rapidly in plain steel cans than in drums or lacquer-coated cans, it is concluded. Access to air during storage—venting—is deleterious for potentially unstable fuels, but sensibly without effect for stable products. The presence of a water lever tends to minimize gum formation during storage.

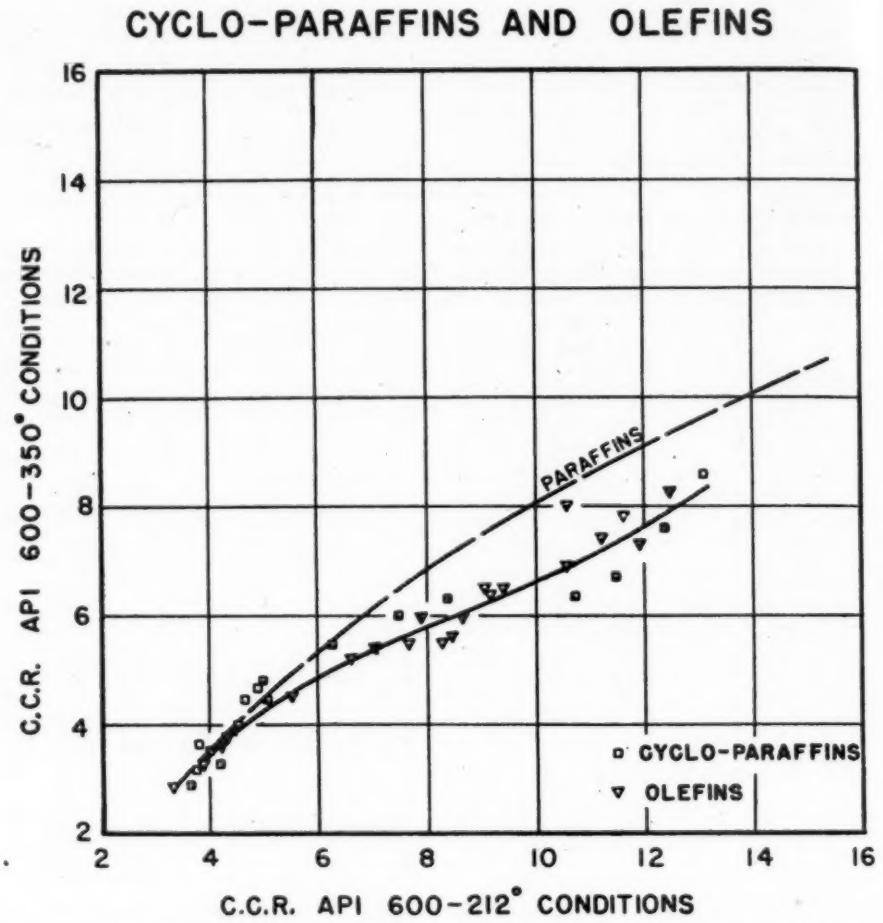


Fig. 1—Comparison of critical compression ratios of cyclo-paraffins and olefins, with paraffins for reference, at two different engine conditions. Note the paraffins are relatively "insensitive"

Project Progress Report On Component Parts of Gasoline

The paper by C. E. Boord, Director API Research Project 45, on "The Component Parts of Gasolines" is in the nature of a progress report on the synthesis, purification and determination of physical properties of low molecular weight hydrocarbons. At first glance the preparaton of these materials by purely laboratory methods which are not commercially applicable has little practical significance. Ordinarily they would not be attempted in the plant laboratory. The methods are laborious, expensive, time-consuming and the yields small. A gallon of gasoline made this way might cost thousands of dollars and be no better in today's cars than a conventional fuel.

Some of these compounds are present in today's gasolines in vanishingly small quantities; others in relatively large amounts. To separate them from a commercial gasoline would be more expensive than by synthesis and, according to this report, the means are at hand to synthesize any or all hydrocarbons known to be in gasolines.

The importance of the work reported

The shape of things to come

The human capacity to create progress out of problems is the one common denominator in every forward step ever made in industrial science. And no one man has ever held all the answers.

Successful and productive creative engineering has always been the product of many minds and many talents, honed to razor sharpness by constant, challenging experience.

It is a unique pooling of brain-power, more than any other factor, that accounts for the important contributions to petroleum refining credited to Kellogg over the past 35 years.

Because of those facts, we place the greatest emphasis on our company's pool of "know how", for the better processes and better machines of tomorrow will logically come from the same source that created them in the past—specialized talents and high caliber minds coordinated and concentrated on the same problem.

PETROLEUM ENGINEERING DIVISION

THE M. W. KELLOGG COMPANY

ENGINEERS TO THE PETROLEUM INDUSTRY

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by Dr. Boord is in the fact these individual components are available in pure state for determination of their physical and chemical properties, through which means can be developed for their identification in, say, gasoline. Those which prove to be of deleterious character can be avoided insofar as possible in producing commercial material. By the same token, in designing a "super gasoline" due regard can be taken for those particular components which have proven themselves to be particularly desirable. This actually was done during the late war, especially with aviation gasolines.

Extending this thought still further a gasoline made from these pure materials can be used for special-purpose testing in which some unusual feature is to be emphasized.

The pure hydrocarbons serve still another purpose. Sufficiently pure, they can be and are supplied (by National Bureau of Standards and another API project) as standards for the calibration of infrared and ultraviolet spectroscopes, used in the control of such processes as alkylation, isomerization and light-ends utilization, as well as in chemical plants. The physical constants on high-purity products, the spectrographic "fingerprinting" of individual hydrocarbons and advancements in spectrographic analytical techniques made possible by standardization are permanent scientific and commercial advances.

While the work of this group, directly, will not be translated into actual refinery procedures, indirectly, through the interpretations of data by chemists and refinery engineers, it will continue to play an important part in refinery operation. The refiner now is as much a chemical manufacturer as he is a "refiner."

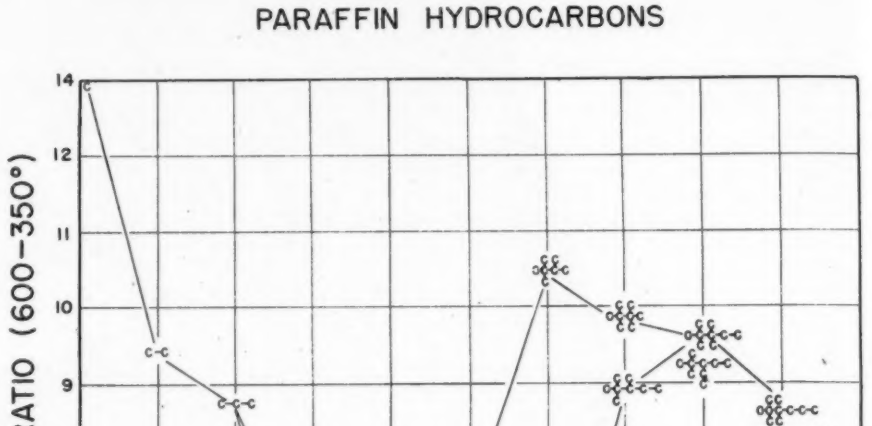

PARAFFIN HYDROCARBONS
CRITICAL COMPRESSION RATIO (600—350°)
NUMBER OF CARBON ATOMS IN MOLECULE
* ESTIMATED FROM OTHER DATA

Fig. 2—Comparison of critical compression ratio and the number of carbon atoms in paraffin hydrocarbons. The effect of structure in molecules having the same number of carbon atoms is very apparent. The lines connect similar longest straight-chain structures

Knock Tendency Correlated With Molecular Structure

Similarly the work reported by W. G. Lovell, "Engine Knock and Molecular Structure of Hydrocarbons" will not directly affect refinery operation. In essence, this group takes the pure hydrocarbons produced by Dr. Boord's workers and performs antiknock determinations on them, in blends, leaded and unleaded, and under various operating conditions with standard and supercharged engines.

This has more immediately practical value than the synthesis work, since these data are more related to ultimate use. Actually, the group's purpose is to correlate knocking tendency with respect to molecular structure and determine the effects with individual hydrocarbons of tetraethyl lead on knock rating. As a result, it now is possible to get a very good general picture of the behavior of a compound with few engine tests on about a pint of fuel. Also, a study of the components of a given fuel in terms of what happens with the pure individual hydrocarbons permits an advance prediction of probable performance in an engine.

It has been found, for example, that addition of tetraethyl lead may increase the knock tendency of certain hydrocarbons, make no difference with others and reduce knocking of still others. Some are high, others low speed knockers. The engine operating conditions under which the tests are made (i.e. Research vs. Motor methods) thus become of great importance. Today this is called "sensitivity" and is reflected in the "high-" and "low-jump" gasolines currently being marketed wholesale under price differentials favoring those in the "high-jump" classification.

An indication of the way hydrocarbons knock in relation to molecular structure and in terms of number of carbon atoms in the molecule is shown in Figs. 1 and 2, respectively, taken from Mr. Wheeler's paper. Fig. 1 compares critical compression ratios of the same hydrocarbons at two different engine conditions with paraffin behavior indicated for reference, since this class of compounds is relatively "insensitive." (Iso-octane has a ratio close to 7 under both conditions, corresponding to 100 octane number.) Fig. 2 rates various paraffins as to structure and number of carbon atoms vs. knock tendency under one engine condition.

Such data as are high-lighted in the bulk of Mr. Wheeler's paper are of interest to both engine manufacturers and refiners. The former must build engines to fit available fuels and the latter desires to produce a quality fuel of high consumer acceptance. Basically the higher the compression ratio possible without knocking the greater the power and efficiency of the engine.

An experimental engine now is under test which requires 100 octane (Research) fuel, has a compression ratio of 12.5 to 1 although of almost conventional design otherwise. It performs comparably with those engines in current autos on less than two-thirds the fuel. Fuel for such an engine is not now being manufactured in quantity, but could be. Such pure hydrocarbons as di-isobutylene, triptane and others have the requisite characteristics. The value of Project 45's work in permitting the design of such an engine, as well as the fuel, thus becomes obvious.

NEW FURFURAL SOLVENT LUBE PLANT

(*Continued from page* 496)

effective without, in effect, creating sufficient pressure drop with the second valve. Control of this operating condition by placing the motor valve in the coolant line was not considered due to the possibility of destructive shock pressure (water hammer) in the effluent water line to the cooling tower.

Below the oil inlet to the treating tower are two specially designed draw-off wells from which streams are withdrawn and cooled for return to the tower. The rate of flow and degree of cooling removes heat at these points, resulting in a gradual lowering of temperature toward bottom of the treating column. Flow is adjusted by means of flow proportioning needle valves in discharge of the intercooler pumps and manometer type flow indicating meters.

The raffinate recovery system offers another change from earlier units in the omission of a dry solvent flash section. The total raffinate mix is charged directly to the raffinate stripper which has an enlarged section above the flash zone to provide for the relatively large vapor volume. The liquid residue drops into the lower section for steam stripping. The amount of stripping steam required is small and condensation of the steam and solvent together does not greatly increase the size of the CBM system in which the solvent is finally recovered.

The pressure flash tower is equipped with an automatic draw-off arrangement from a total draw-off tray to permit removal of a small stream of down flow liquid. It has been found that small amounts of corrosive organic acid compounds which result from any decomposition of the furfural are concentrated at this point. Withdrawal of a small side stream removes these compounds from the extract recovery system. The side stream is directed to the CBM receiver where the organic acids are finally discharged in waste water solution while the solvent content of the side stream is recovered for recirculation to the treating tower.

Based on the just-concluded three weeks' run, however, draw-off of reflux side stream at this point will not be necessary, or only occasionally required. Plant officials consider the fact no decomposition products have been found on analysis of this stream as proof that design of extract and raffinate heaters to avoid thermal decomposition of solvent is both successful and justified.

The rate of side stream withdrawal automatically controls the volume of reflux to the top of the pressure flash tower by means of a recording flow controller with the orifice in the draw-off line and the controlled valve in the reflux line to the tower. It should be added that the gain or loss in acidity of the circulating solvent determines the adjustment of this control.

The solvent purification system is conventional to the furfural extraction units. The lower section of the "A" fractionator is enlarged and serves as a surge tank for dry furfural. This section is equipped with high and low liquid level alarms which operate a system of red and green lights on the control panel. At present, serious thought is being given to a two-way control arrangement which will return excess solvent to storage or bring in fresh make-up solvent to the system.

Earlier units have all had cast iron bubble decks in the recovery system towers, with the exception that aluminum trays were used in the pressure flash tower above the feed inlet where corrosion is at its maximum. The CRA unit is equipped with light weight sectional trays of all stainless steel construction which are expected to combat effectively the mild corrosion of the dilute organic acids in the system. They are arranged for ease of access for inspection and replacement with a minimum number of shell manholes. The stripping towers are necessarily of small diameter and special tray designs were developed to permit assembly and dismantling in the small vessels.

Throughout the unit, extreme care has been taken to reduce the loss of solvent to a minimum. Two separate drainage systems have been installed; one to handle the usual drainage of oil or water, and the other to accumulate drainage from these points where solvent may be included. The latter empties into the slop tank from which the material is gradually reworked in the recovery system. Even solvent handling pumps, Fig. 3, are equipped with dual drains.

The structural steel work is finished in black, and all uninsulated vessels and piping are covered with aluminum paint. The insulation on large vessels is of the block type, with a covering of corrugated aluminum sheeting which gives a startling but pleasing appearance. (See cover photo. Hot lines are covered with block type insulation. Preformed to fit, and wrapped with aluminum sheeting. The heater stacks are painted black and the insulated walls finished in aluminum paint. A concrete slab, 90 ft., x 120 ft., has been provided in front of the process building and encompassing all equipment. Further improvements are supplied by a 6 in., layer of white stone throughout the process area.

A rather complete educational program was extended to the operating personnel prior to the start-up. All were given the opportunity to operate a continuous furfural pilot plant on various type of stocks from which they obtained a sound knowledge of operating conditions, product quality, yield, etc. In addition, a number of discussion type classroom periods were held in which start-up and shut-down procedures, operating technique and problems, lube oil specification, and the like were presented by technical and supervisory personnel.

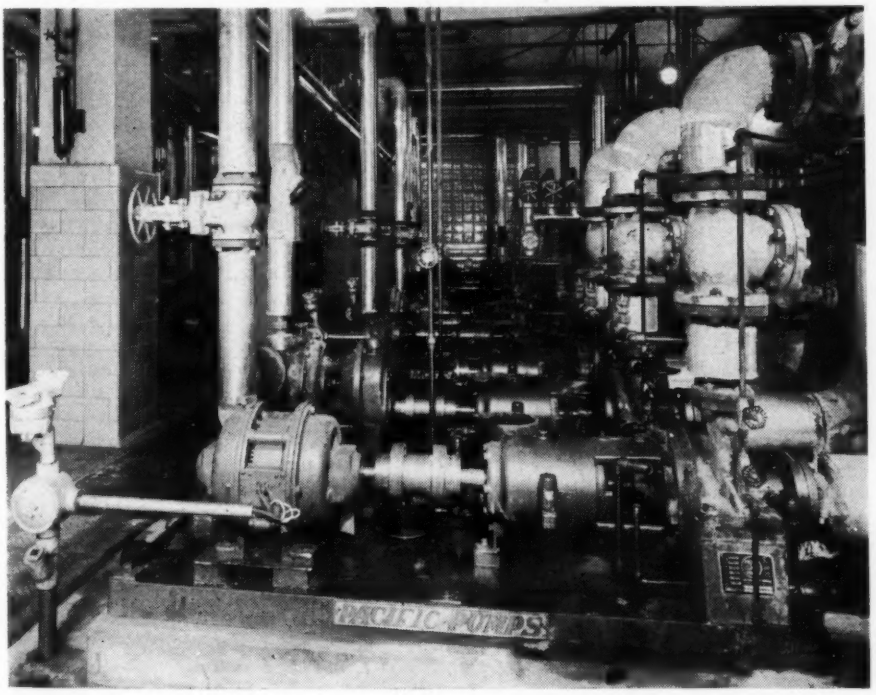
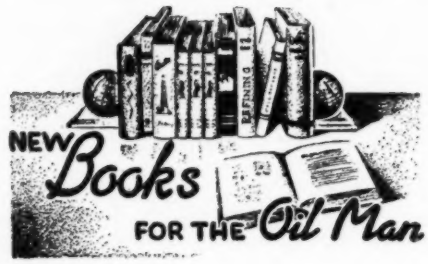


Fig. 3—View of modernistic furfural unit pump room: note glass brick windows, tile wall and painted floor. First three pumps handle treating tower intercooler liquid, followed by "A" and "B" fractionator column reflux and charge pumps. Solvent pumps are in far background



All Organic Reagents Covered In New Volume on Analysis

Organic Analytical Reagents, Vol. I, by Frank J. Welcher, 6 x 9 in., 442 pages, indexed, stiff cloth binding, $8.00 individual volume; $7.00 in the series.

The principal purpose in preparing *Organic Analytical Reagents* was to assemble in one place a description of all organic compounds used in analytical work, and to present a discussion of the methods employing these reagents, the author states in the preface.

Every attempt has been made to bring the latest available information into the volume. Many obviously inferior reagents and methods have been included so that the treatment may be complete. It is felt that an inferior method, with suitable modifications, may be made useful for some purposes. Methods have been included for the preparation of most compounds listed.

Dr. Welcher is associate professor of chemistry in the Extension Division of Indiana University.

Uniform Symbols for Chemical Engineering in New Standard

Letter Symbols for Chemical Engineering, ASA Z10.12-1946, 8 x 10½ in., 16 pages.

Covering 163 letter symbols, this new American Standard is designed to give chemists and chemical engineers a uniform system of "shorthand" for use in mathematical calculations and are not to be confused with symbols designating chemical elements or groups.

A general section covers such concepts as acceleration, diffusity, entropy, molecular weight, surface tension, thermal conductivity and the like. Other sections deal with heat transmission, fluid flow, evaporation, humidification, gas absorption and extraction, distillation, drying, sedimentation, filtration, screening and sampling, crystallization, etc.

The standard was developed under a representative committee of which J. H. Perry, technical investigator development department, E. I. du Pont de Nemours & Co., Inc., was chairman.

Sponsoring organizations were American Association for the Advancement of Science, American Institute of Electrical Engineers, American Society of Civil Engineers, American Society for Engineering Education, and American Society of Mechanical Engineers. Much of the original work was done by the American Institute of Chemical Engineers.

Note: Copies of ASA Z10.12 may be obtained at 50c each direct from the American Standards Association, 70 East 45th St., New York 17, N. Y.

Copies of all books reviewed here may be ordered from the Reader's Service Department, Petroleum Processing, 1213 West Third St., Cleveland 13, for the prices listed, postpaid, unless indicated otherwise. Ohio purchasers please add 3% tax.

Institute of Petroleum Issues Latest Edition on Methods

Standard Methods for Testing Petroleum and its Products, Eighth Edition, Institute of Petroleum; 5½ x 8½ in., 576 pages, illustrated, indexed, paper binding, $4.00.

The new 8th edition of the British Institute of Petroleum's *Standard Methods* includes 8 new methods. These comprise procedures for the estimation of metals in unused lubricating oils, methods for examination of the tendency of grease to corrode copper, and of the resistance to oxidation of turbine oils, a method for the determination of the flash point of liquid asphaltic bitumen, and a modification of the Schwartz method of estimating TEL in motor fuel.

Some amendments have been made to 15 of the previous methods, and a few minor amendments to the two methods for determining knock rating of aviation fuels (weak mixtures) and of motor fuels (I. P. motor method).

The bromination method for determination of TEL in motor fuel has been withdrawn, in view of the availablity of more rapid and reliable techniques.

Book on Heterocyclic Compounds Was Needed in Organic Field

The Chemistry of Heterocyclic Compounds, by Avery A. Morton, 6 x 9 in., 556 pages, stiff cloth binding, illustrated, indexed, $6.00 (1946).

That there was a need for this book is voiced by the author in his preface:

"A generous third of the compounds listed in Beilstein have heterocyclic nuclei; over half of the types of compounds produced by nature have heterocyclic systems; the greater share of the drugs and medicinals and nearly all the alkaloids contain such structures; the large majority of the colors produced by nature and by man have these nuclei as essential components. Yet this wealth of chemical interest, and much more, is scarcely touched in the average textbook."

The subject is a natural and logical continuation of the study of aliphatic and aromatic chemistry: the three classes constitute the natural subdivisions of organic chemistry. However, the former are far better known.

Dr. Morton's book is not a reference book and is not intended as such. Rather its purpose is to present a broad and comprehensive picture of the field, furnishing suggestions for fruitful topics for research.

With the petroleum processing industry today at the threshold of what will probably be its greatest advances, it is well that such a book as this one has been published.

Dr. Morton is professor of organic chemistry at the Massachusetts Institute of Technology.

COMMENTS FROM READERS

In the boxed material on page 327 ("Processing Coal into Liquid Products May be Practicable in a Few Years," PETROLEUM PROCESSING, May, 1947) you make a number of critical comments on the synthetic fuels work of the Bureau of Mines. I believe this arises from your misunderstanding of the way in which this work is conducted.

The Bureau of Mines' program has been worked out in close collaboration with the petroleum and coal industries. There is an Industry Advisory Committee including, for example, Mr. Murphree, Mr. Keith, and myself, and this Committee meets at intervals to discuss the government program. The frank opinions of the members of the Committee are solicited by the Bureau of Mines. The government program may be regarded as essentially the program of this Advisory Committee which is made up of representatives from private industry. The program may deserve criticism, but it should be realized that this criticism should eventually fall upon those of us who represent private industry.

I believe the Committee has been unanimous in its feeling that the government money should be spent primarily upon projects which are not directly competitive with the development work of private industry. It has been stressed that government work should be (1) of a fundamental character in the whole field, and (2) of a developmental character only in the parts of the field which do not appear at the moment to be sufficiently attractive economically to justify large expenditures on the part of private industry. The program of the Bureau has satisfied these specifications.

Eugene Ayres
Gulf Research & Development Co.

PERSONALS

PETROLEUM TECHNOLOGISTS IN THE HEADLINES

Dr. Arthur B. Hersberger, divisional director of research and development for Atlantic Refining Co., has been named chairman of the Philadelphia section of the American Chemical Society for 1947-48.

Dr. Hersberger

Named to the Section's executive committee were: **Prof. Floyd T. Tyson** of Temple University, retiring chairman, **Prof. H. A. Alsentzer,** University of Pennsylvania, **Dr. R. A. Connor,** Rohm & Hass Co., and **John M. McIlvain,** Atlantic Refining Co.

Dr. Hersberger has been with Atlantic since 1936 and has served in research and supervisory capacities in the fields of asphalt, fuels, additives, polymers and petroleum chemicals.

* * *

The degree of Doctor of Science was conferred on **George G. Oberfell,** vice president in charge of research and development for Phillips Petroleum Co., by the University of Tulsa during its Golden Anniversary Commencement. It was the 10th degree conferred on persons not students at the school.

Dr. Oberfell received his bachelor of science degree from Miami University, Oxford Ohio, in 1910, and was instructor in chemistry there for two years. He was junior chemist with the U. S. Bureau of Mines at Pittsburgh, Pa., until 1916 when he joined the Ohio Fuel Supply Co. During World War I he served as a Captain in the Chemical Warfare service. He joined Phillips research department in 1925. In 1928 he became president of the Philgas Co. and in 1935 was made vice president in charge of research and development and a member of the executive committee of Phillips Petroleum Co. He is also a member of its board of directors.

* * *

The resignation is announced of **Dr. D. R. Blumer** and **Dr. J. D. Gibson,** both research chemists in the Research Department of Phillips Petroleum Co., Bartlesville.

Dr. Blumer has taken a position with the Naval Ordnance Project at the University of Minnesota, while Dr. Gibson, who is Treasurer of the Oklahoma section of the American Chemical Society, has gone with Carbon and Carbide Chemical Corp., Oak Ridge, Tenn.

* * *

Dr. C. A. Hochwalt, director of the Central Research Department for Monsanto Chemical Co., at Dayton, Ohio, has been elected a vice president of the company.

He was at one time on the research staff of General Motors Corp., and also was promotion manager of Ethyl Gasoline Corp. prior to 1926, at which time with Dr. C. A. Thomas, now also with Monsanto, he organized the Thomas & Hochwalt Laboratories at Dayton.

While with General Motors he assisted in the development of tetraethyl lead, and at Monsanto he has collabrated in the development of monomeric styrene, Cerex, leavening agents and other chemicals and processes.

Dr. Hochwalt has been active in the work of the National Defense Research Committee and assisted in the development of robot bombs. He was at the Bikini atom bomb test last July.

* * *

T. A. Boyd has been elected president of the American Society for Testing Materials. Official notice of election was given at the annual A.S.T.M. meeting in Atlantic City last month.

Mr. Boyd received his B.S. degree in Chemical Engineering from Ohio State University in 1918, and started his research career with the Dayton Metal Products Co. When General Motors took over the company in 1920 he went to the GM Research Division Laboratories. In 1923 he became head of its Fuels Research section, where later with Kettering and Midgley he discovered the anti-knock effects of the liquid compounds of lead.

He has been a member of the A.S.T.M. for many years. From 1931 to 1946 he was chairman of the Committee on Petroleum Products and Lubricants. He now serves on the Methods of Testing Committee and is a member of the Detroit District Council for the Society.

* * *

Dr. S. J. Meisenburg, formerly assistant superintendent in charge of the gas alkylation and cracking departments at Shell Oil Co.'s Wood River, Ill., refinery, has been transfered to New York, where he will be assistant manager of research and development.

Dr. Meisenburg started with Shell in 1935, when he was employed in the research laboratory after receiving his doctorate in chemical engineering from the University of Michigan. Following various assignments at Wood River, Arkansas City, East Chicago and New York, he became superintendent in 1944.

Succeeding him at Wood River will be **A. H. Garrison,** until recently assistant superintendent of Shell's Houston plant. He also started with Shell at Wood River and was transferred to Houston in 1938.

Technical Meetings For Oil Men

July

16th, Western Petroleum Refiners Association, Regional Technical meeting, Leonard Refineries, Inc., Alma, Michigan.

29th, API Lubrication Committee, Executive Committee meeting, Skytop Inn, Skytop, Pa.

September

1-4, American Society of Mechanical Engineers, Fall meeting, Hotel Utah, Salt Lake City, Utah.

8-9, American Society of Mechanical Engineers, Industrial Instruments and Regulators Division, Chicago.

8-12, Instrument Society of America, 2nd National Instrument Congress and Exhibit, Stevens Hotel, Chicago.

15-17, National Butane-Propane Association, Convention, Jefferson Hotel, St. Louis.

15-17, American Chemical Society, Division of Petroleum Chemicals, 112th National meeting, Waldorf-Astoria, New York.

17-18, American Petroleum Institute Lubrication Committee, Traymore Hotel, Atlantic City.

17-19, National Petroleum Association, Traymore Hotel, Atlantic City.

28-Oct. 2, American Institute of Mechanical Engineers, Petroleum Division, two day technical meeting in conjuction with regional meeting, Denver, Colo.

29-Oct. 1, American Institute of Chemical Engineers, Hotel Statler, Buffalo, N. Y.

October

6-8, American Society of Mechanical Engineers, Petroleum Mechanical Engineering, Conference, Rice Hotel, Houston.

11, California Natural Gasoline Association, Fall meeting, Ambassador Hotel, Los Angeles.

16-18, National Lubricating Grease Institute, 15th Annual meeting, Edgewater Beach Hotel, Chicago.

20-22, American Society of Mechanical Engineers, Fuels Division, Joint meeting American Society of Mining and Metallurgical Engineers, Coal Division, Cincinnati, Ohio.

21-25, Pacific Chemical Exposition, Section of American Chemical Society, San Francisco Civic Auditorium, San Francisco.

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EDITORIAL COMMENTS

WIDENING HORIZONS

Is $30,000,000 More Needed For the Liquid Fuels Program?

BILLS now before Congress (H.R. 2161; S. 134) would extend the life of the Bureau of Mines' Synthetic Liquid Fuels research program another three years and make an additional $30 million available to carry it out. The initial $30 million appropriation was approved in 1944, and the program was then due to be completed in 1949. As now proposed, it would continue into 1952.

The Bureau claims 40 to 50% of the added funds are necessary because of increased costs, and that the remainder will be spent on lengthened operation of demonstration plants. Although the original plan was to operate the plants for only one year, the Bureau now believes longer operation necessary to obtain the accurate data needed for cost and quality studies.

Five months ago the Bureau had different reasons for requesting the added money—to put increased attention on research into the Fischer-Tropsch process. That process, although considered most promising by industry, has so far been accorded only a minor portion of the Bureau's attention.

At the completion of the program, the Bureau expects to have established a foundation for private industry inauguration of synthetic fuel production, including detailed cost data.

With the purpose back of the research program—to secure basic data on how to produce liquid fuels synthetically, including processes, equipment and costs, there can be no argument. The manner in which the Bureau has been carrying out its program, however, is open to criticism.

Many industry technologists are of the opinion that the Bureau, in typical bureaucratic fashion, has been entirely too wasteful and extravagant in its expenditures. As pointed out in this column last year (NPN Technical Section, Mar. 6, 1946, pg. R-240), a good portion of the Bureau's funds have gone for permanent-type laboratories and offices, built to last a lifetime instead of the length of the program.

It is also said that the Bureau frequently attempts to operate on too large a scale. Equally reliable cost and operating data for the purpose of the present program, industry men believe, could be obtained from laboratory and pilot plant studies, without the expense of installing large demonstration plants, such as the 200 b/d coal hydrogenation unit at Louisiana, Mo.

Another criticism of the program has been that the Bureau too often ignores entirely the advice of its petroleum industry advisory committee. That committee, which has no standing except in an advisory capacity, is reported to have suggested in the early days of the program that the Bureau limit its coal hydrogenation work to fundamental research and a small-scale pilot plant, instead of building the 200 b/d demonstration plant.

The committee is also said to have recommended that the Bureau direct its shale retorting work toward the development of a continuous process, rather than using the N-T-U batch-type retort, which some engineers consider already obsolete.

Both suggestions were ignored.

Industry wants the government's help in the field of research on synthetic liquid fuels, and desires to cooperate in a program that would correlate with the established research programs of the oil companies. The Bureau, on the other hand, seems inclined to bull its own way ahead regardless of what industry recommends and despite the cost or possible results.

Before Congress gives the Bureau an additional $30 million it should take a searching look at what the Bureau has actually accomplished in three years with the first $30 million, and should require an itemized account of exactly what the Bureau proposes to do with the new funds.

It should also set up some method of obtaining closer control over the program to assure coordination with industry's needs. The solution, perhaps, is an Advisory Board—composed of representatives of industry, the armed services and the Bureau, and empowered to actually direct the course of the program.

READERS' comments and opinions will be welcomed by the editors of PETROLEUM PROCESSING, 1213 West Third Street, Cleveland 13, Ohio

Revived API Refining Division Broadens Committee Programs

THE Refining Division of the American Petroleum Institute has resumed its normal functioning again after a lapse during the years when refiners individually and as a whole devoted all efforts to the PAW wartime program. Its present and proposed activities cover enough phases of refining so that almost every individual refiner and natural gasoline operating staff can find there at least an approach to the solution of operating difficulties arising from common problems such as corrosion and waste disposal, for example.

The Division's standing committees have maintained their organizations, many of them carrying on important functions during the war, and they now offer their services again on problems general to refiners. The committees and their subgroups cover such important subjects as corrosion of refinery equipment, disposal of plant wastes, standards for equipment, analytical research methods, commercial test methods for products, training programs for refinery workers, correlation with the automotive industry on common research problems, among others. The committee personnel includes men with long practical experience in refining and they bring the best thinking of the industry to their assigned subjects.

At the recent general meeting in St. Louis of the Refining Division, the chairman of these committees, in making their reports, asked company representatives to bring to their attention pressing problems of today in plant operations and in the functioning of research and development departments. This suggestion if carried out will help direct the committee work along lines of practical help to the largest possible number of refiners.

The St. Louis meeting of the API Refining Division was exclusively a refiners' meeting. Heretofore, its mid-year sessions have been jointly with the Production Division. Attendance and interest shown in the current sessions warrant continuing separate meetings.

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This is the third in a series of advertisements reviewing the B&A Fine Chemicals commercially available to American Industry today from the Baker & Adamson Division of General Chemical Company.

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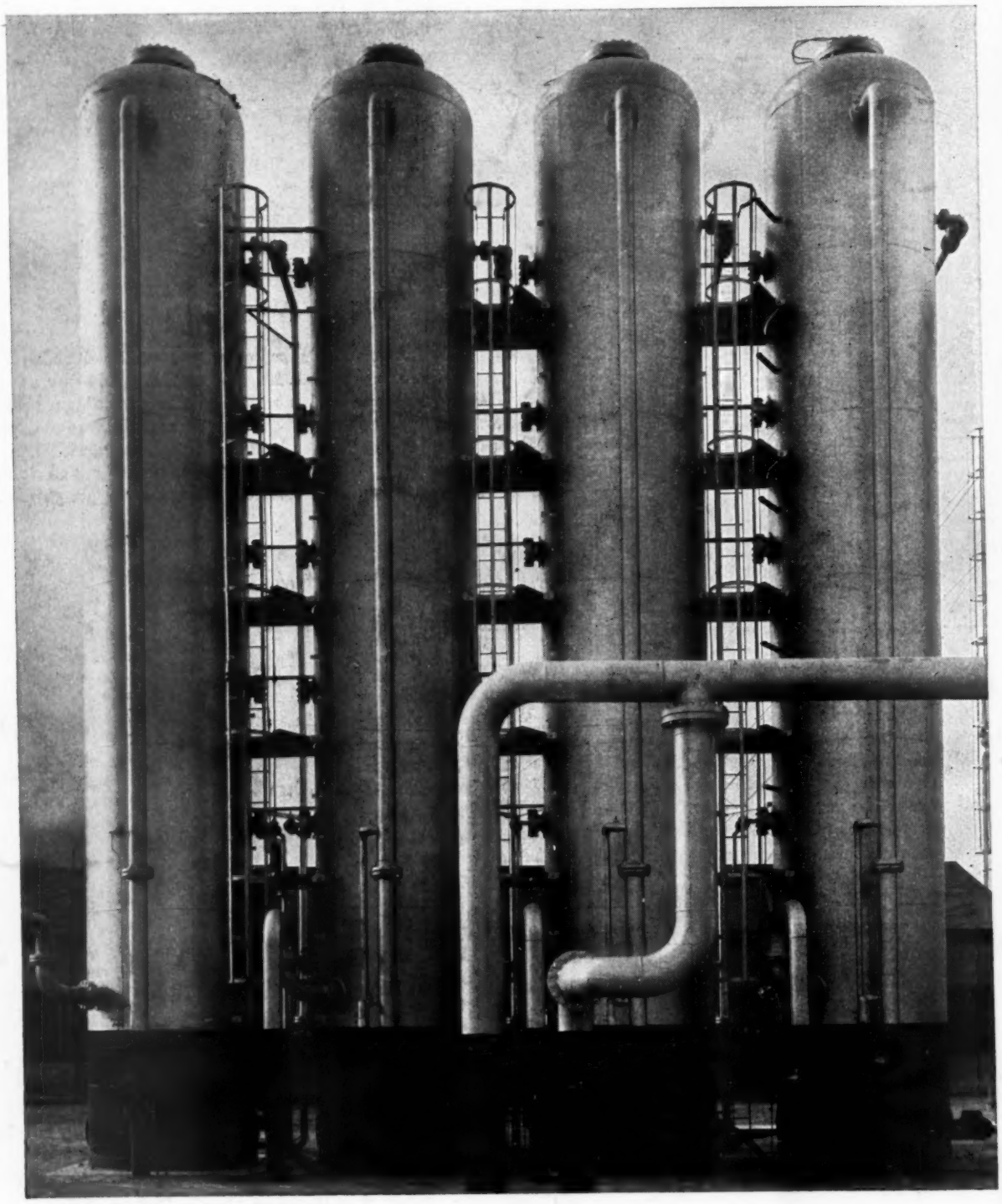

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